HELSINKI SCHOOL OF ECONOMICS (HSE)
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OVERVIEW AND RISK ANALYSIS OF COLLATERAL USAGE IN OTC DERIVATIVES MARKETS

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Abstract
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Purpose of the study

The first purpose of the study is to give an overview of the collateral usage as a counterparty risk mitigation technique in OTC derivatives markets, as it is a rather new phenomenon in the market. The emphasis will be on the current market situation and trends, and on the legislative and regulative frameworks of the collateral usage. Secondly, the aim is to identify the risks related to the collateral usage and to study them in more detail, both qualitatively and quantitatively. The focus will be on the residual counterparty risk and legal risk.

Data and research methods

All of the risks related to collateral usage are examined qualitatively and residual counterparty risk is evaluated quantitatively. The risk analysis is based on imaginary case setting. The qualitative risk analysis is based on a synthesis of current market practices and collateral research and articles, and on interviews made among collateral practitioners. The quantitative risk analysis is based on model based Monte Carlo –simulation, in which interest rate swap values are simulated, and on collateral amount determination methods provided by International Swaps and Derivatives Association Inc. and Bank for International Settlements. The historical swap rate data for the simulation are extracted from Reuters and the historical price and yield data for the collateral riskiness evaluation from the EcoWin Pro. The methods used in the residual counterparty risk evaluation are Credit at Risk –analysis and basic volatility and correlation analyses.

Results

The qualitative and quantitative frameworks proved to be a good starting point to evaluate the collateral risks, as no standard way exists yet. Qualitative analysis showed that most of the risks are to some extent managed. Although deemed critical, especially in OTC derivatives markets, legal risk proved to be significantly alleviated by the ongoing trend of legislative and regulative reforms and similarities between case countries' legislations. The use of highly rated professional central counterparties will in turn reduce the liquidity risk, custody risk and concentration risk related to collaterals. Operational risk turned out to be critical, especially for new collateral practitioner, due to collateral management requirements. In general, as a result, systemic risk is efficiently reduced. Quantitative analysis showed that the residual counterparty risk is of high importance and exists due to high OTC derivative exposure volatility and collateral instrument riskiness. However, there are ways to reduce the effect of these contributors to residual counterparty risk and if used properly, the collateral insufficiency to cover the underlying exposure could be greatly reduced. The most critical ways are ISDA's independent amounts cushioning against exposure volatility and BIS's haircuts protecting against collateral instrument riskiness.

Keywords

Collateral, credit risk mitigation, risk analysis, counterparty risk, legal risk, Monte Carlo – simulation, OTC derivatives, interest rate swaps

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Tutkimuksen tavoitteet

Työn ensimmäisenä tavoitteena on antaa yleiskuva vakuuksien käytöstä vastapuoliriskin pienentämiskeinona OTC-johdannaismarkkinoilla, sillä vakuuksien käyttö on melko uusi ilmiö markkinoilla. Erityisesti huomiota kiinnitetään nykyiseen markkinatilanteeseen ja trendeihin vakuuksien käytössä, sekä vakuuksiin liittyvään lainsäädäntöön, sääntöihin ja ohjeistuksiin. Toisena tavoitteena on määritellä vakuuksien käyttöön liittyvät riskit ja analysoida niitä tarkemmin, sekä kvalitatiivisesti että kvantitatiivisesti. Pääpaino on vakuuksien käytöstä huolimatta jäljelle jäävässä vastapuoliriskissä sekä oikeudellisessa riskissä.

Aineisto ja tutkimusmenetelmät

Kaikkia vakuuksien käyttöön liittyviä riskejä analysoidaan kvalitatiivisesti ja vakuuksien käytöstä huolimatta jäljelle jäävää vastapuoliriskiä kvantitatiivisesti. Riskianalyysi perustuu kuvitteelliseen case-tapaukseen. Kvalitatiivinen riskianalyysi muodostuu nykyisen markkinakäytännön ja olemassa olevan vakuustutkimuksen sekä vakuuksien käytön ammattilaisten keskuudessa tehtyjen haastatteluiden synteesinä. Kvantitatiivinen riskianalyysi perustuu Monte Carlo –simulaatioon, jossa simuloidaan esimerkkikoronvaihtosopimuksen arvoja, sekä International Swaps and Derivatives Association Inc.:n ja Bank for International Settlements:n tarjoamiin vakuudenmäärittelytapoihin. Historiallinen korkotieto simulointia varten on saatu Reutersista ja historialliset hinta- ja tuottodatat vakuuksien riskillisyyden arviointia varten on saatu EcoWin Pro:sta. Vakuuksien käyttöön liittyvän residuaalin vastapuoliriskin arviointi perustuu Credit at Risk –analyysiin sekä yksinkertaisiin volatiliteetti- ja korrelaatioanalyyseihin.

Tulokset

Sekä kvalitatiivinen että kvantitatiivinen riskianalyysi osoittautuivat hyväksi lähtökohdaksi arvioida vakuuksien käyttöön liittyviä riskejä. Kvalitatiivinen analyysi osoitti, että useimmat riskit on hallittu ainakin jossain määrin. Osoittautui, että oikeudellista riskiä pienentävät meneillä olevat lainsäädännön ja sääntelyiden uudistukset sekä lainsäädäntöjen yhtenevyys esimerkkimaiden välillä. Korkeasti luottoluokiteltujen keskitettyjen vastapuolien käyttö puolestaan vähentää vakuuksiin liittyvää likviditeetti-, säilyttäjä- sekä konsentraatioriskiä. Operatiivinen riski osoittautui kriittiseksi, erityisesti uusille vakuuksien käyttäjille, vakuuksien hallintaan liittyvien vaatimusten vuoksi. Yleisesti seurauksena on systeemisen riskin tehokas väheneminen. Kvantitatiivinen analyysi osoitti, että residuaali vastapuoliriski on kriittinen ja sitä esiintyy OTC-johdannaisten luottovasta-arvojen volatiliteetin ja vakuusinstrumenttien riskillisyyden vuoksi. On olemassa keinoja, joilla näiden osatekijöiden vaikutusta residuaaliin vastapuoliriskiin voidaan vähentää. Jos keinoja käytetään asianmukaisesti, vakuuksien riittämättömyyttä kattaa alla olevan transaktion luottovasta-arvoja voidaan vähentää. Kriittisimmät keinot ovat ISDAn itsenäiset määrät, jotka vaimentavat luottovasta-arvojen volatiliteetin vaikutusta, sekä arvonleikkaustekijät, jotka suojaavat vakuusinstrumenttien riskillisyydeltä.

Avainsanat

Vakuus, luottoriskin pienentäminen, riskianalyysi, vastapuoliriski, oikeudellinen riski, Monte Carlo –simulaatio, OTC-johdannaiset, koronvaihtosopimus

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1 Introduction

1.1 Opening words

Collateralisation is a widespread credit or counterparty risk mitigation technique, which resembles margin requirements of exchanged traded derivatives. Other practices and procedures used for the same purpose in OTC derivatives markets are for example counterparty credit limits, master agreements, close-out netting and clearing houses. Rather than pricing the credit risk inherent in OTC derivatives instruments, firms can use collaterals to mitigate the risk. Collateral instruments can vary depending on the activity and the transaction to be secured, from low-risk cash and government bonds to more risky equity (see Chapter 2.2.1). In the context of OTC derivatives, cash and government securities are mostly used as collateral (ISDA, 2003). Also the collateral transfer can take different legal forms, for example a pledge or a title transfer (see Chapter 3.2.3). Collaterals are used by many participants especially in Europe and in North America in many contexts in financial markets, like lenders in credit markets, counterparties to derivatives transactions, clearing houses, members of payments systems etc. Also central banks use collaterals for open-market operations.

Collaterals are nowadays widely used to protect OTC derivatives against counterparty risk. Using collaterals, however, does not eliminate all risk. In fact, collateral usage may expose the collateral users to other kinds of risks, such as legal risk, liquidity risk, operational risk, custody risk, concentration risk and systemic risk. And most importantly, using collaterals does not eliminate all of the counterparty risk either. In addition, the changing risk profiles of the collateral instruments themselves may expose the collateral taker to additional source of risk. Recent literature has recognized indeed some possible risks related to collateral usage (see e.g. CPSS&ECSC, 1998; CGFS, 1999; IOSCO&CPSS, 1999).

1.2 Motivation for the study

The interest in risk management in general, and especially in credit risk management, has recently been spurred by a few events that clearly show the increased need for new and innovative risk mitigation techniques. Such events have been e.g. the Russian debt default, the Asian currency crisis and the LTCM failure in the late 1990s. The increased attention to risk mitigation has expanded the use of collaterals as one technique to reduce risk and also raised

the interest in the collateral itself as such technique. The total amount of collateral in circulation is currently estimated to be about $719 billion, an increase of 65% from year 2002 (ISDA, 2003). Recent credit situations have indeed demonstrated the effectiveness of collateral as a mitigant against counterparty risk, as losses after collateral liquidation have been kept to a minimum (ISDA, 1999).

OTC derivatives are chosen as the object instrument of the study because the collateral usage related specifically to OTC derivatives transactions has been growing most rapidly in recent years. OTC derivatives are the most widely collateralised group of financial instruments (ISDA, 2003) and there has been a growing trend toward full collateralisation in OTC derivatives markets. The vast majority of the collateral programs currently in place support fixed income, currency and equity derivatives (ISDA, 2003). Thus, the markets are currently going through changes in the market practices and it is especially of the interest of banks involved in these markets to study the changes and their effect. Also the enormous growth in the use of OTC derivatives in general adds to the motivation; OTC derivatives represent major share of the derivatives market at the moment and while exchange traded derivatives do not present credit risk, OTC derivatives do.

The trend at the market place of OTC derivatives is currently towards the practices in exchange traded derivatives markets, i.e. full collateralisation. Exchange traded derivatives have traditionally been margined so that they do not present any credit risk. OTC derivatives, however, do present this risk. Even though collateralisation is designed to mitigate this risk as fully as possible, some residual risk is always left due to the volatility of the underlying exposure and the collateral itself.

As proposed in the joint study of the Committee on Payment and Settlement Systems (CPSS) and the Euro-currency Standing Committee (ECSC) of the central banks of the Group of Ten countries (1998) derivatives counterparties should pay attention to the legal, operational, liquidity and custody risks arising from the use of collaterals. Also the effective management of these risks is encouraged. Risks related to collateral usage have been recognised in some studies. These reports explain in general the risks related to the collateral usage, but no empirical study or evidence is included. Their contribution to the study of collateral risks is thus the acknowledgement of the risks. Hence, there exists no academic research of collateral

risks, i.e. there has not been any widespread study of the relevant related risks and no real world empirical surveys have been made.

One additional motivation for the study is the fact that collateralisation of OTC derivatives is quite a new phenomenon especially in Finnish financial markets. Thus it is of general interest of financial institutions to see what risks lie ahead when starting to use collateralisation as a risk mitigation technique. Because of the newness of the practice, there is only limited amount of collateral usage data available in Finland. Thus the study of this paper is based on an imaginary case study with examples and assumptions as realistic as possible.

1.3 Purpose of the study

The purpose of the study is to give an overview of the collateralisation as a counterparty risk mitigation technique in OTC derivatives market, and to focus on the risks related to collateral usage. Although the rationale behind using collaterals is the risk mitigation, collateral itself exposes the collateral receiver and provider to other risks. Collateralisation is indeed a method to reduce or mitigate risk by transforming it to other risks (CGFS, 2001). Risks are transferred from business transactions to be associated with risk mitigation instruments themselves, i.e. the risks that are the subjects of mitigation are exchanged for collateral-related risks. Thus, it is a risk diversification strategy.

The paper also focuses on the current and future trends in collateral usage, especially in respect with the possible scarcity problem of the preferred collateral, which changes the risk profile of the collateral pool. The emphasis will also be on the changing legal regime of the collateral usage. These are the two major risk areas related to collateral usage that are highlighted throughout the study and studied in more detail in the empirical part of the paper.

The purpose of the paper divided into five subsections is:

- To have an overview of collateral usage in OTC derivatives markets
- To highlight the trends
- To recognize the relevant collateral risks
- To study legal risk in more detail
- To study residual counterparty risk in more detail

In more detail, the purpose of the study is to analyse the risks related to collateral usage qualitatively and quantitatively. The focus is on the analysis of the net counterparty risk exposure faced by the collateral receiver after taking collateral, i.e. the residual counterparty risk, on the overcollateralisation and counterparty risk faced by the collateral provider and on the legal risk. Emphasis is especially put on the changing risk profile of the collateral. The study is conducted in a Finnish financial institution environment setting to determine the risks a financial institution faces in its collateral usage and to analyse the extent of these risks. Simulation is used to evaluate possible future scenarios, in which swap values are simulated and the adequacy of collateral amounts are estimated. The focus will be on the exposure volatility and collateral riskiness as contributors to residual counterparty risk. Legal and other collateral risks are evaluated qualitatively.

1.4 Structure of the study

This study is divided into nine chapters. In Chapter 2 collaterals as risk mitigation technique are described in more detail. The chapter focuses on the current market situation, the benefits and costs of collateral usage and the trends in collateral usage. Third chapter takes a closer look at the legal and contractual aspects of the collateral use emphasizing the current collateral legislation, agreements, transfer forms and collateral amount determination. Chapter 4 briefly summarises the previous research on collaterals. After that, in Chapter 5, the specific risks related to collateral usage in OTC derivatives market are described in detail, and in Chapter 6 the imaginary case, the methodology and data of the study are presented. In Chapters 7 and 8 the qualitative and quantitative analysis of the paper are carried out. Chapter 9 summarises the study and presents conclusions and suggestions for further research.

2 Collateral usage as a risk mitigation technique

2.1 Definition of collateral and related concepts

Collateralisation is a widespread credit or counterparty risk mitigation technique, which resembles margin requirements of exchanged traded derivatives. In general *collateral* can be defined as a property or an asset provided by one party to another to mitigate the collateral taker's credit risk on the collateral provider. In other words, the collateral provider delivers the collateral to secure an obligation to the taker. The primary reason for using collateral is to protect against a default of a counterparty, but there are also other reasons present at the market (see Chapter 2.3.). Other practices and procedures used to mitigate counterparty risk in

OTC derivatives markets are for example counterparty credit limits, master agreements, close-out netting and clearing houses[1]. Other related counterparty risk mitigation techniques in general are for example credit derivatives, on-balance sheet netting and guarantees.

This paper will approach collateral usage from the point of view of Finnish financial institutions, such as banks and securities firms, using collaterals when operating in OTC derivatives markets. *OTC derivatives* markets consist of non-standardized derivatives transactions that are privately traded and settled between the counterparties and the contracts are usually negotiated between large financial institutions' dealers and end-users, or other dealers (CPSS&ECSC, 1998). OTC derivatives are for example interest rate and currency swaps, caps, floors and forward rate agreements (FRAs)[2]. This paper will take interest rate swap as the object instrument when examining the effects of collateralisation on OTC derivatives counterparty risk.

The risk that a counterparty will fail to perform its financial obligations can be termed as *credit risk, counterparty risk or default risk* depending on the characteristics of the transaction in question. Also, the names describing derivative risks are profuse in the literature causing confusion. However, the essence of the risk meant here is that the counterparty owing money cannot pay and defaults its obligation. In OTC derivatives markets the term used in most cases is counterparty risk and collaterals are directly used to mitigate the counterparty risk that arises from transactions designed to hedge against e.g. market price risk of other instruments or transactions.

There are two types of counterparty risks involved in OTC derivatives transactions; pre-settlement risk, i.e. replacement cost risk, and settlement risk (see e.g. Cooper and Mello, 1991; Kuprianov, 1993). In the first case, if the OTC derivatives counterparty defaults before the settlement, the non-defaulting counterparty usually tries to replace the defaulted transaction and thus might incur losses. The second risk is relevant only to OTC derivatives counterparties whose contracts provide for an exchange of payments or a delivery of the reference asset. The assessment of the first risk type requires estimating the default probabilities and exposures, both current and potential. Collaterals are used to affect these

[1] See e.g. CPSS&ECSC (1998) or Hull (2000) for more details
[2] For more about OTC derivatives instruments, see e.g. Kuprianov, 1993.

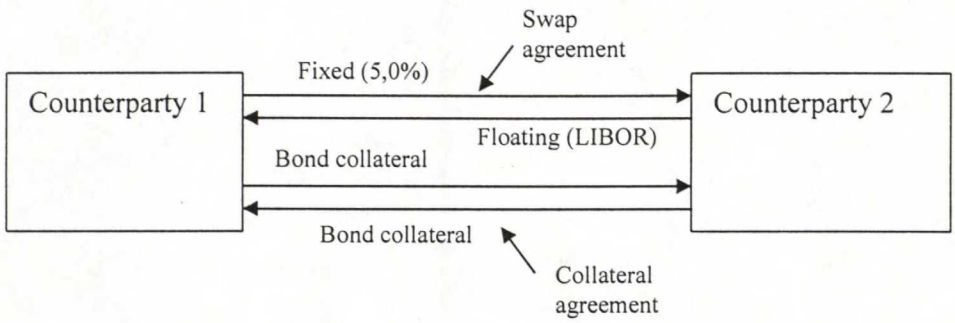
exposures and the potential loss, as they have the impact of reducing both current and potential exposures.

To define *a collateralised transaction* in the context of banking business, the new Basel capital accord by Basel Committee on Banking Supervision (BCBS, 2001b; BCBS, 2003; later Basel II) determines that to be one in which

- 'banks have a credit exposure or potential credit exposure to a counterparty[3]; and
- that credit exposure or potential credit exposure is hedged in whole or in part by collateral posted by the counterparty or by a third party on behalf of the counterparty.' (BCBS, 2003)

Figure 1 illustrates the use of collaterals in OTC derivatives transactions to mitigate counterparty risk. In this example the transaction is an interest rate swap with one counterparty paying fixed, e.g. 5%, and receiving floating, e.g. LIBOR, interest rate payments and the other counterparty paying floating and receiving fixed interest rate payments. The transaction is secured by for example government bond collateral by both counterparties, i.e. the collateral agreement is a so-called 'two-way' agreement.

Figure 1 An interest rate swap transaction collateralised with bond collateral



The counterparty receiving collateral can be named as collateral receiver or taker, and the opposite counterparty is called either collateral giver or provider. Also words transferee and transferor, respectively, are used. All of these terms are used interchangeably in this study. Terms counterparty risk, credit risk and default risk are also used interchangeably in this paper, unless otherwise indicated.

[3] The exposure can take the form of a loan of cash or securities, of securities posted as collateral, of a commitment or of exposure under an OTC derivatives contract.

2.2 Current market situation of collateral usage

2.2.1 Collateral instruments

Preferred collateral

In principle, very broad range of assets could be used as collaterals. To find a financial instrument that is the most efficient as collateral, the following aspects of the instrument should be evaluated (adapted from ISDA, 1998):

- **Liquidity.** The higher the liquidity, the better the instrument as a collateral, because in the event of a default the collateral can to a high degree of certainty be liquidated and the proceeds can be used to cover the credit loss. A minimum liquidity threshold can also be set.
- **Volatility.** Low volatility of collateral is desired because extreme price changes affecting collateral value can add to counterparty and operational risk during periods of extreme market volatility due to the time lag between margin call and the delivery.
- **Credit rating.** Bonds used as collaterals need to have credit ratings and also some minimum rating for bonds to be accepted as collaterals needs to be established. For equities, listing on major exchanges can serve as an indicator of the eligibility.
- **Time remaining to maturity.** This measure of time to maturity is determined instead of the original time to maturity, to seize the actual time horizon or instrument tenor. The shorter the time to maturity, the lower the probability that large price changes could occur.
- **Correlation with exposure.** Strong negative correlation with the underlying exposure is to be avoided. In that case, if the value of the underlying exposure were to increase, the collateral value would decrease at the same time resulting in insufficient collateralisation.
- **Correlation with the counterparty.** Positive correlation with the collateral giver's credit standing is to be avoided. Instruments exhibiting such correlation are for example instruments issued by the collateral giver.

Currently used collateral instruments

The most widely used collateral instruments in OTC derivatives markets according to International Swap and Derivatives Association's (ISDA) survey 2003 are currently US dollar cash, Euro cash and government securities. According to the survey, over 90% of the banks and corporations accept US dollar cash and about 85% deliver US dollar cash as collateral.

The respective percentages for Euro cash are about 75% and just under 70%. US and EU government bonds are the most extensively used government bonds, but to a lesser extent than the corresponding cash instruments; cash represent 70% of collateral received and 74% of collateral delivered, while government securities represent only 13% and 19%, respectively. The reason for the extensive use of these instruments is evidently that these are the highest quality instruments to be used as collaterals in terms of liquidity, credit risk and volatility. Other instruments that are used as collaterals are for example other cashes, Japanese government securities, bonds issued by agencies, corporate bonds, letters of credit and equities, but they are used to a lesser extent (ISDA, 2003).

Collateral instruments accepted by Basel II

The regulatory capital treatment affects the use of instruments as collateral. For example, many dealers accept only collaterals that are recognized as reducing credit risk by their regulators and thus are also recognized in capital adequacy requirements (CPSS&ECSC, 1998). On the other hand, many banks accept wide range of assets as collateral to mitigate risk irrespective of any capital treatments (BCBS, 2000).

The former regulations of the Bank for International Settlement, i.e. the first Basel capital accord (BCBS, 1988; later Basel I)[4], recognized collaterals as risk mitigation techniques but only to a limited extent. Only cash, and securities issued by OECD central governments and by specified multilateral development banks were accepted as collateral instruments.

In the new Basel capital accord (BCBS, 2001b; BCBS, 2003)[5], a much broader range of collateral instruments is accepted. Two approaches to the collateral treatment under the Standardised approach to credit risk are defined; the simple approach and the comprehensive approach[6]. Depending on the approach different set of instruments is accepted as eligible collateral instruments. The new Basel capital accord recognizes the following collateral instruments eligible under both approaches to the collateral treatment (with a few exceptions):

- Cash on deposit with the bank which is incurring the exposure
- Gold

[4] See Chapter 3.1.4. for more details about Basel I.
[5] See Chapter 3.1.4. for more details about Basel II.
[6] For more information about the approaches, see Chapter 3.1.4.

- Debt securities rated by a recognised external credit assessment institution where these are either:
    - at least BB- when issued by sovereigns and public-sector entities (PSEs) that are treated as sovereigns by the national supervisor; or
    - at least BBB- when issued by other issuers[7]; or
    - at least A-3/P-3
- Debt securities not rated by a recognised external credit assessment institution where these are
    - issued by a bank; and
    - listed on a recognised exchange; and
    - qualify as senior debt;

  and
    - all rated issues of the same seniority by the issuing bank are rated at least BBB- or A-3/P-3 by a recognised external credit assessment institution[8]
- Equities that are included in a main index;
- Equities not included in main index, but traded on a recognised exchange[9]; and
- Undertakings for Collective Investments in Transferable Securities (UCITS) and mutual funds[10].

In addition, under the other approach within the Internal ratings based approach to credit risk in Basel II, called the foundation internal ratings based approach, two ranges of collaterals are recognised. *The eligible financial collaterals* include the same eligible collaterals as introduced under the standardised approach. The other category is so called *eligible physical or IRB collaterals* including receivables, specified commercial and residential real estate collaterals.

2.2.2 Collateralised transactions

Currently banks and other financial institutions use collaterals primarily in three business areas, namely in OTC derivatives transactions, in repurchase agreements and in payments and settlements (CGFS, 2001).

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[7] Including banks and securities firms.
[8] In addition, the lending bank has no information to suggest that the issue justifies a rating below BBB and the supervisor is sufficiently confident about the market liquidity of the instrument.
[9] Only under the comprehensive approach.
[10] Subject to daily public quotations of unit prices and in simple approach, restricted to investing in the above mentioned securities and in comprehensive approach, allowed to invest in equities not included in main index.

OTC derivatives transactions

Banks collateralise counterparty exposures arising from using OTC derivatives instruments to hedge certain market risks. Exchange-traded derivative transactions have traditionally been collateralised in the form of margin payments required by clearing houses. The trend has been towards full collateralisation also in OTC derivatives markets and the collateralisation of OTC derivatives positions is nowadays extensive, though not predominant (CGFS, 2001). OTC derivatives have been collateralised since the early 1990s (ISDA, 1999).

OTC derivatives transactions are the most widely collateralised group of financial products (ISDA, 2003). According to the ISDA survey, all respondents[11] collateralise at least some types of OTC derivatives. Fixed income, FX and equity derivatives are the most widely supported OTC derivatives. For example, 54% of the trade volume and 48% of the exposure of fixed income derivatives were collateralised among all of the respondents. Also in the survey conducted one year earlier all of the participants collateralised OTC derivatives (ISDA, 2002).

Repo transactions

Another important field of activity where banks use collaterals is the cash market, in the form of repo or reverse repo transactions. In repo transactions, and in general in securities lending transactions, securities are temporarily exchanged for cash with equivalent value and the securities lender has an obligation to buy back the same securities or equivalent securities at specified date and price. Generally, the securities serve as a collateral to secure the cash obligation and the repo transaction can be compared to a collateralised cash loan. Thus, collateral is an inherent part of repo transactions (CGFS, 1999; CGFS, 2001; IOSCO&CPSS, 1999)

Repo transactions are the second largest group of products that are collateralised by banks and other financial institutions right after OTC derivatives (ISDA, 2003). According to this ISDA survey about 70% of the respondents use collaterals to support repo transactions.

[11] The Survey sample consists of 73 firms, whereof 59 banks, 11 securities broker-dealers, 2 energy firms and one insurance company.

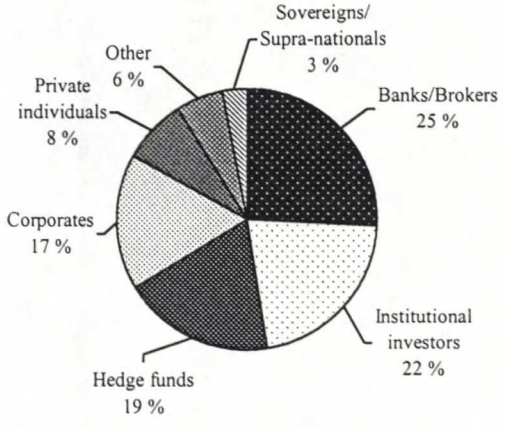
Payments and settlements

The third main business field in which banks use collaterals is payment and settlement systems. Collateralisation provides credit risk mitigation, as well as enhanced liquidity. The use of collaterals is especially important in countries where real time gross settlement (RTGS) systems are used. In these systems the intra-day credit needed to provide a high availability of liquidity is possible through collateralised basis only (CGFS, 2001). Another relevant benefit of collateral use in payment and settlement systems is that the participants to the system do not have to assess the creditworthiness of the other party as thoroughly anymore (BIS, 2001).

2.2.3 Collateralised counterparties

Banks and brokers (26%), and institutional investors (22%) are the two largest counterparty groups with which banks and firms collateralise their transactions. Institutional investors are such as insurance companies, pension funds and money managers. The third largest collateralised counterparty group is hedge funds (19%). It should be noted, however, that the relative proportions of the collateralised counterparties depend on the size of the collateral program in a bank or a firm. Banks' high proportion in every size group is because the dealers in banks operate on a collateralised basis, meaning that interbank market operates mainly on collateralised basis. Graph 1 presents a more detailed distribution of counterparties by counterparty type. (ISDA, 2003)

Graph 1 Distribution of collateralised counterparties by counterparty type



Source: ISDA Margin Survey 2003

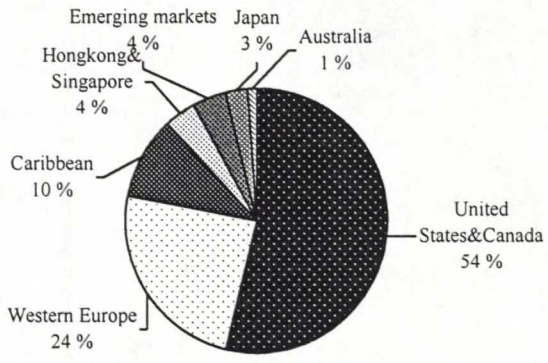
It is expected that there is going to be a change in the composition of the collateralised counterparties in the near future, mainly due to institutional investors moving towards

increased use of more complex derivative products and sovereigns using more and more OTC derivatives (ISDA, 2002).

2.2.4 Collateralisation across geographical regions

North America and the developed Europe are the dominant areas for collateral use. Around 54% of the collateralised counterparties are in United States and Canada, 24% are in Western Europe and 10% in Caribbean (ISDA, 2003). The reason for high proportion of Caribbean counterparties is the increased use of collaterals in hedge funds. Also the proportion of South Africa has increased recently in conjunction with the increased sophistication of the financial markets (ISDA, 2001). Graph 2 depicts the distribution of collateralised counterparties by geographic areas in more detail.

Graph 2 Distribution of collateralised counterparties by geographic area



Source: ISDA Margin Survey 2003

Knowing the locations of the collateralised counterparties is crucial for two reasons. First, legal uncertainty plays a major role and raises concerns in collateral agreements, i.e. the jurisdiction of the country where the counterparty is located affects the enforceability of the collateral agreement. Second, the location of the collateral management function depends largely on the location of the counterparty. (ISDA, 2001)

2.2.5 Collateralisation in Finland

Not much is known of the current situation of collateral usage in OTC derivatives markets in Finland. No special studies covering the subject have been conducted. 59 banks responded to the ISDA Margin Survey 2003, of which only one bank was Finnish and only three banks were Scandinavian. Based on this information, with caution it can be said that the survey

gives some indication on the situation of collateral usage currently in Finland. However, the results of the survey are only aggregate and the data from the Finnish bank might differ significantly from the aggregate data. The lack of data implies the fact that the collateralisation of OTC derivatives is quite a new phenomenon in Finnish financial markets.

Something is however known about the Finnish collateral markets in general. All credit transactions with the central bank are collateralised. Usually these transactions are loans. The collaterals are given usually in the form of a pledge and title transfer is not widely acknowledged. (Rahoitusvakuustyöryhmän mietintö, 2003)

2.3 Benefits and costs of collateral usage

The benefits and costs or negative externalities of using collaterals are various ranging from individual counterparty price benefits to financial systems stability and from individual fees to disturbing effects in times of stress.

2.3.1 Benefits

The main effect of the collateral usage from the risk management point of view is to replace the risk of the counterparty to the transaction with the credit risk of the issuer of the collateral (ISDA, 1998). Collaterals serve as risk mitigation technique. According to a survey conducted by ISDA the main motivation why banks use collaterals is indeed to mitigate credit or counterparty risk (ISDA, 2003). Most of the respondents to the survey, namely 80%, chose the credit risk mitigation to be the most important driver for using collaterals.

Collaterals mitigate credit or counterparty risk through three channels:

- First, collaterals reduce the possible losses in the case of default in the form of the liquidation value of the collateral. (CGFS, 2001)
- Second, collaterals have the effect of reducing the likelihood of a default. This occurs because providing collateral encourages the collateral giver to engage in lower risk transactions. The more the collateral giver has provided collateral, the more it has to lose in the event of default. This is the so-called '*incentive effect*' of collaterals. (Coco, 2000; Bester, 1987)
- Third, giving collaterals makes it possible for the providers of collateral to signal their creditworthiness. This helps to overcome the asymmetries of information present in the market. If the collateral provider is quite safe, it can signal this by providing more

collateral than what more risky debtors would provide. This is the so-called '*signalling effect*' of collaterals. (CGFS, 2001; Bester, 1985)

Another important reason for collateral usage named also in the ISDA survey is regulatory capital savings (ISDA, 2003). The new Basel capital accord (BCBS, 2001b; BCBS, 2003) gives some allowances for banks from the capital requirements if certain requirements concerning collaterals are fulfilled. Those institutions that have to follow the Capital Accord can get a reduction in the risk weighting of the collateralised exposures up to 0%, depending on the collateral type. This frees up capital to be used in other purposes and reduces regulatory costs. Other benefits arising from collateral usage, though not especially relevant for this study, are presented in Table 1.

Collateralisation leads to more favourable financing conditions for the collateral provider. With regard to *price effect* of collateralisation, using collaterals normally reduces the credit spreads charged for the credit, thus increasing trade activity, competitiveness and revenues. In the context of *quantity effects* of collaterals, collateral usage enables a market participant to enter to more complex markets or maintain itself in a market that otherwise would be unavailable (ISDA, 2002; ISDA, 1998; CGFS, 2001).

The initial logic for using collaterals arises from the presence of asymmetric information about the creditworthiness of the other party of the transaction and from credit rationing between the counterparties in the market (see e.g. Bester, 1985). Thus one of the main benefits of collaterals in a larger scale is the reduction of these asymmetries. This in turn leads to better access of participants to different markets and thus also to better functioning and efficiency of markets as a whole. Also the stability of the financial system is enhanced by the use of collaterals. Because collateralisation reduces the risks faced by individual counterparties, the overall stability of the financial system increases. Especially in certain markets, like OTC derivatives markets, which do not discriminate effectively in prices and which thus are prone to credit rationing, particularly in the times of market stress, the benefits of collaterals are indisputable. (CGFS, 2001)

2.3.2 Costs and negative externalities

The main shortcoming of the collateral usage is that it does not necessarily eliminate all of the risk and therefore usually some counterparty or credit risk is left after collateralisation (CGFS,

2001). In other words there could always be some uncovered exposure left due to changes in collateral value or exposure value. Either the collateral value decreases leading to insufficient collateral value. Or the value of the exposure changes adversely leading to uncovered positions, before additional collateral is posted again. In addition, collateral usage gives rise to a new bundle of other risks, such as legal risk, operational risk, liquidity risk, custody risk, concentration risk and systemic risk. (The risks associated with collateral usage, especially in OTC derivatives, are explained in detail in Chapter 5.)

It is doubtful if collaterals really reduce the probability of default. This is because giving collaterals may impose liquidity constraints on the collateral provider. Providing collateral also means that the provider faces credit risk for the part of the receiver. This is because also the receiver can default in which case the collateral provider may lose the collateral. Another adverse impact on collateral provider is the so-called overcollateralisation situation, in which case more collateral is posted than actually needed. (CGFS, 2001) These are actually again new risks arising from the collateral usage that the collateral provider has to face and are dealt with in Chapter 5 in more detail.

The general concern related to the collateral usage is proper management of the collateral risks. Collateral usage entails new sources of risks, which in turn require proper management. Thus, continuous risk management by the collateral receiver is necessary. Using collaterals may also expose external third parties to risk. These are in most cases unsecured creditors. The impact of collateral usage on unsecured creditors arises form the diminishing value of the remaining assets (after pledging collateral) of the collateral provider. Another important but adverse effect of collaterals in a social context is that collateral usage can conduce to pressures that threaten the financial markets in times of stress. (CGFS, 2001)
Table 1 summarises the benefits, costs and negative externalities of collateral usage.

	Benefits	*Costs and negative externalities*
Collateral receiver	Mitigates counterparty risk by replacing it with other risks	Does not eliminate all of the counterparty risk
	Enables regulatory capital savings	Exposes to new bundle of risks
	Substitutes for an assessment of counterparty's creditworthiness	Brings about tangible costs and fees (operational and legal)
	Increases market liquidity	
	Increases profit making potential	
Collateral provider	Leads to more favourable financing conditions (reduced credit spreads), *price effect*	Does not necessarily reduce the probability of default (liquidity constraints)
	Enables to enter into or maintain in a market otherwise unavailable, *quantity effect*	Causes counterparty risk and overcollateralisation risk
		Lowers incentives for monitoring counterparty's creditworthiness
		Causes opportunity and other costs
Financial markets	Reduces asymmetries of information present in the market	Increases concerns over proper collateral risk management
	Enhances stability of the financial system	Exposes external third parties (unsecured creditors) to risk
		Conduces to pressures in times of stress

Table 1 Benefits, costs and negative externalities of collateral usage for collateral receiver, collateral provider and financial markets in general

2.4 Trends in collateral usage

2.4.1 Growth and determinants of collateral usage in the future

Collaterals are nowadays widely used to protect OTC derivatives against counterparty risk. Particularly in recent years, there has been a rapid growth in the use of collaterals in wholesale financial markets in general (CGFS, 2001). And it is reasonable to expect the growth to continue in the market. For example, in the ISDA 2003 Survey (ISDA, 2003), it is estimated that about 38 500 collateral agreements for OTC derivatives are in place, compared to around 28 140 in 2002 and 16 000 in 2001. Further growth of 22% is estimated for year 2003.

There are several factors that will affect the future trends in the use of collaterals. Demand for collaterals will likely be determined by two factors, namely the participants' perceptions of counterparty's creditworthiness, which is affected by narrowing profit margins, and by participants' willingness to accept credit risk, on which, in turn, will impact credit risk management advances and transparency (CGFS, 2001). Also the availability and cost of

substitutes for collaterals and consolidation in financial markets will affect the demand for collaterals (BIS, 2001). Close substitutes are for example credit derivatives and securitisation. Consolidation, on the other hand, means relying on central counterparties in transactions.

An important determinant of collateral usage in the future will be of course the supply of collateral instruments. The changing patterns of issuance of collateral instruments will determine the availability of preferred collaterals. There have been concerns about the rate at which the collateral demand and collateral supply will evolve and that the demand would grow faster that the supply (CGFS, 2001). Also the regulatory and legislative treatment of collaterals will affect the usage in the future. It will affect the costs incurred by collateral givers by influencing the capital charges faced by banks, and thus partly determine the collateral usage in the future (BCBS, 2001b; BCBS, 2003; CGFS, 2001)[12].

2.4.2 Special challenges

Scarcity of preferred collaterals

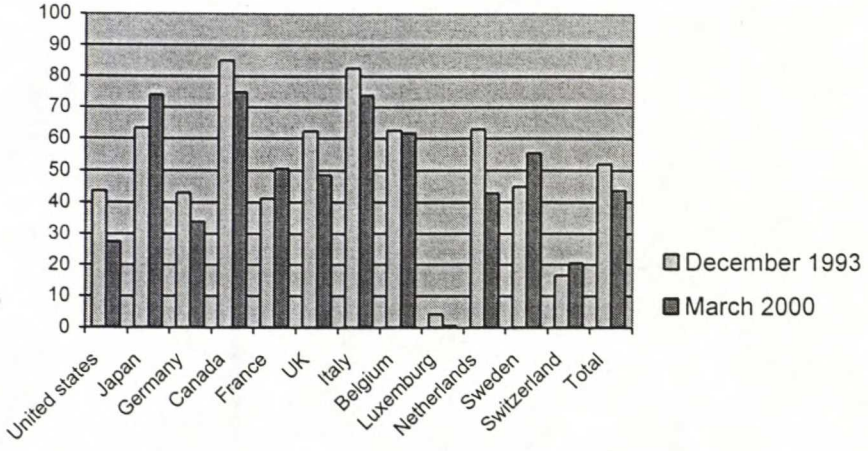
The use of collaterals has increased rapidly alongside the moderate increase in issues of collateral instruments. Especially the issues of preferred collaterals, such as low-risk, high liquidity government bonds, have slowed down. There have been concerns that the demand for collaterals in the future will continue to exceed the supply of preferred collaterals. Indeed, during the last few years the use and supply of collaterals have changed in unpredictable way in both rate and direction. Although there has been little evidence of scarcity of preferred collaterals yet, particularly the growing use of collaterals in payment and settlement systems has raised concerns over demand pressures. (CGFS, 2001)

Many government markets in the world are expanding nowadays quite slowly (BIS, 2003a). Especially the last six months of 2002 showed significant slowdown in the net issuance of debt securities in international markets. The only exception at the moment is the Japanese market, where the market share of government bonds has increased by more than 10 percentage points between 1994 and 2000 (CGFS, 2001). In contrast, for example the US government market has even showed some signs of contraction. Similar patterns have been observed also in many other markets. However, the first six months of 2003 have shown a significant surge in the net issuance in international markets (BIS, 2003c). Graph 3 exhibits

[12] Regulatory treatment and legislation of collaterals are discussed in more detail in Chapter 3.1.

the trend of the government bond market issues in US, Canada, Japan and some European countries between December 1993 and March 2000.

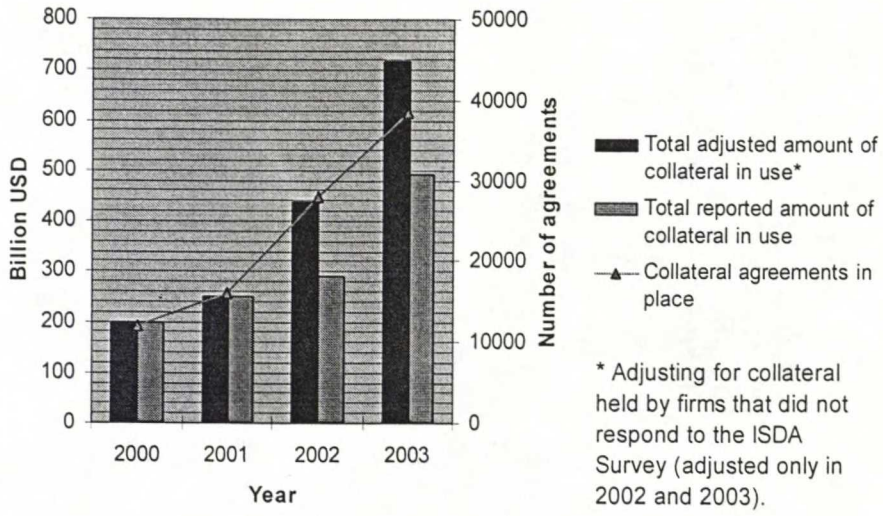
Graph 3 The change in the share of the government bonds of total amounts of bonds outstanding between 1993-2000 (domestic and international issues), percentages



Source: Committee on the Global Financial System, 2001

The recent trend of increasing use of collaterals in new activities can be traced down to four important changes in global market place. First, the transaction volumes and risk exposures have increased as a consequence of general expansion of trading. This has brought about the need for new risk mitigation techniques. Second, the financial activity has expanded globally thus increasing the active participants in the market. New participants have brought new credit risk sources into the market place. Third, the collateral usage has increased substantially in reducing risk in payment and settlement systems. Finally, the financial disturbances during the 1990s have speeded up the use of collateral as a way to reduce counterparty or credit risk. Graph 4 presents the trend between 2000 and 2003 in collateral usage in OTC derivatives markets both in total amounts of collateral in use in billions of dollars and in total amounts of collateral agreements in place. (CGFS, 2001)

Graph 4 Recent collateral usage (years 2000-2003) in OTC derivatives markets expressed in billions of US dollars and numbers of agreements



Source: ISDA Margin Survey 2000, 2001, 2002, 2003

These two parallel trends at the market place will most likely lead to scarcity of preferred collaterals and initially to higher relative collateral prices. This can be seen as a change in the risk profile of collateral instruments. Markets can adjust to the scarcity and higher relative prices principally in two ways: either by substituting collaterals for other counterparty risk mitigation transactions with similar characteristics or by using higher-risk, possibly also less liquid and more expensive collaterals but at the same time adjusting the terms of their collateral agreements to compensate for additional risk. (CGFS, 2001)

A new pool of collateral assets

The attention will be given to the second adjustment approach to the increasing scarcity of preferred collateral in this study. Collateral substitutes are not dealt with. Because the types of collateralised transactions increase, also the need for possible collateral instruments increases. The securities markets continue to grow globally, thus increasing the range of possible assets to be used as collaterals. As explained earlier, in principle, a wide range of instruments could be used as collaterals and Basel II nowadays accepts a wide range of collateral instruments.

The composition of the collateral asset pool will change as a consequence, in one hand, of the contracting supply of low credit risk high volatility assets and, on the other hand, of increasing demand for collateral instruments. New assets have to be taken in to use, assets

such as corporate bonds and debt securities issued by financial institutions. As a consequence of a booming trend in equity issues in Europe also equities are becoming an asset group suitable for collateral usage. Also the new Basel capital accord is allowing banks and firms to accept a wider range of assets. For example, securities such as corporate bonds and equities included in main indexes are now approved.

Changing risk profile of collaterals

The main consequence of the currently changing situation in collateral markets is that the risk profile of the collateral markets will change (see e.g. CGFS, 2001). In other words, the total effect of the possible collateral scarcity is a change in the risk profile of the collateral base. For example as the amount of private sector papers increase as collateral instruments also the riskiness of the collateral base increases, because private sector instruments are usually less liquid and more difficult to value and hedge than e.g. government securities. As the weight of the private sector instruments as collaterals grow, counterparty risk becomes more important. This phenomenon in turn adds to the risks that collateral usage entails to the participants to collateralised transactions. This new feature of increased riskiness in collateral markets will be dealt with in more detail in conjunction with other risks related to collateral usage in Chapter 5.

3 Legal and contractual aspects of collateral usage

3.1 Collateral legislation and regulation

There is more than one law regime affecting the collateral arrangements in Finland. In addition to the national legislation in Finland, e.g. the Credit Institutions Act and Financial Supervisory Authority's (FSA) regulations, the EU directives on collaterals will have an impact on the legislation. Also the Hague conference, in which Finland is a member, will provide some regulations on issues related to collateral use. In addition, the new Basel capital accord affects the collateral activities of banks in Finland.

3.1.1 Collateral legislation and regulation in Finland

The Credit Institutions Act (Laki luottolaitostoiminnasta, 30.12.1993/1607) regulating credit companies in Finland includes general provisions on the risk management of credit institutions (68§). There are parts in the Credit Institutions Act regulating directly collaterals, as well. According to the Act, the credit company cannot rehypothecate the collateral without

the permission of the collateral giver (24§). The law also regulates credit institutions when taking its own shares, cooperative shares, capital loans and debentures as pledges (24a§). The credit institution can accept these instruments as pledges only if they are exchange traded or market securities in the way specified in the Securities Market Act (chapter 1, 3§), if accepting the pledge forms a part of the regular activities of the credit institution and if the pledge has been accepted according to the conventional rules followed in credit institution activities. Also the amount of these instruments that can be accepted as pledges against a loan provided to finance their subscription is limited to 10% of restricted shareholder's equity of the loan granting institution (24a§). There are no separate provisions on the regulatory treatment of collaterals when determining minimum capital requirements.

There are some other laws in Finland that have certain specific provisions affecting collateralisation, for example Commercial Code, Contract Law, Promissory Notes Act, Act on Book-Entry Accounts, Bankruptcy Act, Netting Act, Restructuring Act and Recovery Act. However, only a few of these laws apply directly to financial institutions that are the subject of the study here. Thus the law regime applying to collateral usage in Finnish financial institutions is quite dispersed, and not very specific or extensive.

The regulatory body in Finland giving instructions and regulations related to financial markets is the Financial Supervisory Authority (FSA). In relation to credit risk management and collaterals FSA has given several guidelines. General guideline on credit risk management (Rahoitustarkastus ohje 105.13) amends the credit Institutions Act and applies to all activities that expose credit institutions to credit risk, thus including also OTC derivative transactions. It provides general principles of credit risk management, ranking and monitoring of borrowers etc. In this guideline, general principles concerning collateral in relation to credit policy, credit analysis, exposure decision etc. are given. In the Guideline on the margin requirement related to the use of securities as collateral (Rahoitustarkastus ohje 103.3.) FSA advices to pay attention to the unstable collateral instruments and the possible resulting credit risk. It also gives some standard collateral values for exchange traded securities and urges to follow case-by-case analysis in case of unlisted securities. Finally, General guideline on the risk management of derivatives (Rahoitustarkastus ohje 105.12) urges credit institutions to use collaterals as a credit risk mitigation technique for derivatives transactions. These guidelines are not binding and are thus only advisory by nature.

3.1.2 Collateral legislation and regulation in EU

Collaterals are used throughout the EU to mitigate counterparty risk related to broad range of different financial transactions. Each of the member states has their own legal traditions regarding collateral usage (EFMLG, 2000), thus exposing the participants in the markets to fifteen different legal regimes. This causes uncertainty and is especially cumbersome for participants engaged in cross-border transactions. Hence member states have seen the need to form a unified way to handle collateral within EU.

The legislations related to collaterals in EU member states differ greatly. In many EU member states there are certain requirements on the publicity or registration of the pledge causing costs or delays to the creditor, substitution laws differ from creating a new pledge to changing the nature of the existing pledge, creditors need court orders to be able to enforce their rights to pledged securities and protection from enforcement may be granted, and the re-use of pledged assets is not allowed. On the other hand, the title transfer has not been widely recognised and still in some member states transfers of title are recharacterised as disguised pledges and restrictions related to set-offs in case of title transfers are in place. (EFMLG, 2000)

EU Directive on Settlement Finality (1998/26/EC)

The first step towards integration of the laws governing collateralisation within EU was the 1998 Directive on Settlement Finality. To date, it has been the only piece of European legislation governing cross-border collateralisation. However, it only regulates payment and settlement transactions and the transactions taken by national central banks in EU and the European Central Bank.

The part of the Settlement Finality Directive applying to collaterals is Article 9. It establishes a conflict of laws rule for the EU member states. It states that the rights of a participant to collateral securities provided to it in connection with a system and the rights of central banks of member states and European central bank to collateral security provided to them will not be affected by insolvency proceedings against the counterparty providing the collateral. The collateral security may be realised to compensate the rights. It also provides that if the aforesaid securities and related rights are provided to a participant and the rights are legally recorded in a member state, then the determination of those rights in relation to the collateral securities will be governed by the law of that member state.

EU Directive on Financial Collateral Arrangements (2002/47/EC)

The Financial Services Policy Group meeting under the chairmanship of the Commission of the European Committees has taken further actions toward the regulation of cross-border collaterals. The core aim of the new directive is to strengthen both the pledge and the title transfer approaches and to remove publicity or registration requirements, as well as enforcement requirements. The legally binding directive is intended to disturb the legal frameworks in place in the member states as little as possible, allowing member states either to create a new regime or modify existing laws.

The purpose of this new directive is "to protect the provision of financial collateral on a bi-lateral basis between two parties to a collateral arrangement" (Commission of the European Communities, 2001). The directive will treat only of collaterals and collateral arrangements. The directive applies to public authorities (related to management of public debt or authorised to hold accounts) of member states, central banks, European central bank (and other EU banks), financial institutions subject to prudential supervision (credit institutions, investment firms etc.), central counterparties, settlement agents or clearing houses (and similar institutions regulated under member states' national laws) and to persons other than natural persons provided that the other counterparty is one of the mentioned institutions, thus covering a wide range of participants to financial markets. The financial collateral must be cash or financial instruments and the collateral must be provided to the collateral receiver and the provision evidenced in writing in order for the directive to apply. Also the collateral arrangement has to be evidenced in writing or in a legally equivalent manner.

In short, the directive will restrict any formalities that may be required for putting a financial collateral arrangement into effect or for enforcing the collateral. Also the ways in which the collateral is realised are without any formal requirement. Any 'stay' imposed by e.g. reorganisation procedures on collateral liquidation or close-out netting are removed. The directive allows the re-use of the collateral. The title-transfer is recognized in the directive and recharacterisation of those arrangements is precluded. The directive confirms the validity of close-out netting provisions and ensures that any winding-up or reorganisation proceedings do not have retroactive effects. The directive extends the conflicts of law rule in the Settlement Finality Directive (1998/26/EC) and states that in case of any matters arising in relation to book entry securities, collateral will be governed by the law in which the relevant account is

held (national law). The effect of the directive on collateral usage will be dealt with in more detail in the qualitative part of the study.

The directive has already entered into force and the member states have to comply with this directive by 27 December 2003. Member states are currently implementing the directive to their national legal frameworks.

3.1.3 Hague convention (Convention #36, 13.12.2002)

The Convention on the law applicable to certain rights in respect of securities held with an intermediary (Hague convention #36, 2002) is designed to diminish the legal risk related to legal questions of securities held with an intermediary. This convention is evidently relevant to collateralised transactions, since in many cases collateralised securities are held with intermediaries or custodians. The aim is to make the PRIMA (Place of the Relevant Intermediary Approach) the decisive principle. The PRIMA approach implies that the law applicable to the proprietary rights related to the securities held with intermediaries is the law of the country determined in the agreement between the account holder and the relevant intermediary, provided that the relevant intermediary has operations in this country.

The convention thus determines the law applicable to certain issues related to the securities held with intermediaries. These issues are such as the rights resulting from a credit of securities to an account, the disposition of securities held with an intermediary, the requirements for perfection of this disposition, extinction and priority over other people's interest of interest in securities held with intermediary, the duties of an intermediary to others than the account holder, the requirements for realisation of an interest in securities and entitlements to dividends, income and other proceeds.

The Hague convention will enter into force three months after three countries have ratified it. None of the member countries to the Hague conference have signed it yet. After entering into force, the convention enters into force in a member state three months after the country has ratified the convention. Thus the convention has not entered into force yet and is not binding on any country.

3.1.4 The Basel capital accords (BCBS, 1988; BCBS 2001b; BCBS, 2003)

The Basel I, the first Basel accord, introduced by the Basel Committee on Banking Supervision, was the first step in the regulatory treatment of collateralised transactions from the capital adequacy regulation perspective. The approach taken to acknowledge collateral was the substitution approach. However the role of the collateral in this accord was quite restricted and in general, the accord did not adequately take into account credit risk mitigation techniques.

The new Basel capital accord of 2001 and 2003 instead recognizes credit risk mitigation techniques, like collateral, guarantees and credit derivatives, and proposes the capital treatment of these techniques. The committee preparing the new accord has taken the view that greater recognition of risk mitigation techniques and thus improved risk sensitivity in minimum capital requirements can encourage the banks to improve risk measurement and management of mitigants in general (BCBS, 2001a). Thus the new accord provides capital reductions for various risk reducing transactions and allows for a wider range of credit risk mitigants to be recognized than the previous accord.

The new Basel capital accord sets certain minimum conditions for collateralised transactions (see Chapter 2.1.) and accepts a wider range of collaterals to be used (see Chapter 2.2.1.). In addition, it sets minimum requirements on the collateral instruments and offers different approaches that banks can take for the treatment of collaterals.

The accord sets out certain minimum conditions on collaterals before this credit risk mitigation technique is recognized for capital requirement purposes and any capital relieves can be granted. These conditions relate to legal certainty, correlation with exposure and risk management process of collaterals. First, the conditions related to legal certainty require the collateral documentation to be binding and enforceable in all relevant jurisdictions, the legal mechanism of the collateral transfer to be robust and the collateral rights of the lender to be clear. The enforceability of the security interest has to be confirmed and the segregation of the custodian's own assets must be ensured. Legal opinions on the enforceability of the collateral agreement need to be obtained and documentation of the agreements must be proper. Second, conditions related to correlations require that no significant positive correlation can exist between the credit quality of the collateral giver and the value of the collateral. Finally, robust risk management procedures and processes are claimed to manage risks related to collateral

usage. In addition, some certain qualitative and quantitative disclosure requirements must be fulfilled.

The two approaches in the Basel II, *the simple and the comprehensive approach* to collateral treatment under *the standardised approach to credit risk*[13] in general, are both applicable to banking book[14] exposures, but only the comprehensive approach is also applicable to trading book exposures. Banks can choose only one of the two approaches. *The simple approach* resembles the substitution approach taken in the Basel I. The substitution approach implies that when collaterals are used in certain transactions, also the risk of the issuer of the collateral has to be taken into account by applying certain risk weights in addition to the risk of the counterparty (Keijser and de Haas, 2001). The simple approach exhibits only a few changes to the first accord, e.g. a wider range of collateral instruments is accepted. In general, the simple approach is less accurate as an approach. Collaterals must be pledged for the life of the exposure, and they must be marked to market and revaluated every six months in order for them to be recognised in the simple approach. The other approach to collateral treatment is *the comprehensive approach*. Under the comprehensive approach adjustments called *haircuts* are introduced. Haircuts will be applied to the market value of the collateral and the exposure to reflect different volatilities associated with the respective values. The comprehensive approach allows mismatches of maturity between the underlying exposure and the collateral. As this approach introduces haircuts, it deviates from the earlier Basel I substantially.

Under the other approach to credit risk, *the internal ratings based (IRB) approach*[15], the treatment of collateral depends on the approach taken within the IRB approach. If the bank decides to follow *the foundation IRB approach*, the treatment of collaterals closely resembles the treatment of collaterals under the comprehensive approach of the standardised approach. Under this approach, especially, the amount that is assumed to be recovered in default is affected by the collateral use. If, on the other hand, the bank agrees to take *the advanced IRB*

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[13] The standardised approach to credit risk is one of the two approaches to credit risk proposed in Basel II. This alternative allows banks to use recognized external credit rating institutions' assessments for determining risk weights when calculating capital requirements.

[14] Collateralised transactions are registered in either the trading book or the banking book of a bank, depending on the context in which they are used. Trading book activities are carried out by trading desks and focus on short-term profit-making, while banking book activities focus on longer term banking activities, such as granting of credit. Risks related to trading book activities are usually referred as 'market risks' and, respectively, risks related to banking book as 'credit risk'.

[15] The internal ratings based (IRB) approach allows banks to use their own internal assessments of e.g. probability of default of an obligor. It is further divided into two approaches: foundation IRB and advanced IRB approach. These approaches to credit risk are only available for banks meeting robust supervisory standards.

approach, bank's internal rating models play an important role in reflecting the risk mitigating effects of collateral. In this case, banks can use their own internal estimates of loss given default (LGD), but again taking into account the collateral use. In general, under the IRB approach, banks have great flexibility to consider the effect of risk mitigation techniques.

The committee preparing the new accord has released already its third consultative package of the proposed accord and it intends to release the final version of the accord in the fourth quarter of 2003. The accord is then ready to be implemented by each country at year-end 2006. During this three-year period, countries are expected to adapt and develop necessary systems and processes to comply with the new accord.

3.2 Collateral arrangements

Appropriate documentation of the collateral usage in OTC derivatives transactions is necessary to be able to enforce the interest to collateral. This is especially important in the event of default. The most widely used standard collateral agreements are established by International Swaps and Derivatives Association, ISDA (ISDA, 2003). These are commonly referred to as credit support annexes (CSA). In addition to global standard documentation, there exists also some national non-standard documentation.

The form of the collateral arrangement affects the legal status of the counterparties and the collateral security, and thus has an impact on the legal risk faced by both counterparties. This is why the collateral arrangements are documented and specified separately in the OTC derivatives transactions. In addition, knowing what is included in collateral agreement and how the collateral transfer is structured facilitates the evaluation of legal risks related to collateral usage.

3.2.1 Collateral documentation

Nowadays most of the collateral agreements in OTC derivatives markets are established by using standard legal agreement and confirmation templates (CPSS&ECSC, 1998). Although the OTC derivatives transactions are usually negotiated privately and bilaterally, standard agreement templates are used as a basis of the agreement. ISDA, has established master agreements for the OTC derivatives transactions and *credit support annexes* (CSA) to these agreements to provide a standard template for the collateral usage related to the transactions. Standard documentation offers objectivity, consistency, a body of judicial and operational

experience and can even shorten the negotiation times (ISDA, 1998). ISDA credit support annexes are currently the most widely used standard templates for collateral transactions (see e.g. ISDA, 2003).

At the moment there are five different supplemental documents to the ISDA master agreement. They are based on a different body of law or a method of transferring the collateral. The documents are:

- ISDA Credit Support Annex (New York Law –a pledge approach), 1994
- ISDA Credit Support Deed (English law –a pledge approach), 1995
- ISDA Credit Support Annex (English law – a title transfer approach), 1995
- ISDA Credit Support Annex (Japanese law – a hybrid approach), 1995
- ISDA Margin Provisions, 2001

3.2.2 Collateral transfer forms

According to the ISDA CSAs, there are two ways in which the collateral arrangement can be structured; a pledge or a title transfer. The nature and location of the collateral, the nature and location of the parties to the collateralised transaction and the intended use of collateral determine the transfer form that will be chosen (ISDA, 1998). Whether the collateral arrangement is organised by a pledge or a title transfer impacts on the enforceability of the collateral agreement, especially in the event of default, and thus affects the legal risk.

Pledge

A pledge is based on creating a security interest in the securities or cash posted in favour of the collateral receiver (ISDA, 1998). Securities or cash are delivered either directly to the collateral taker or to a specified custodian (ISDA, 1998). The collateral provider however continues to have the ownership, i.e. the proprietary interest, in the securities or the cash, but in the case of default the collateral receiver has the right to sell or otherwise liquidate the collateral. The CSA for collateralisation of OTC derivatives in US is structured as a pledge and thus this is the mostly used form of arranging collateralisation in US (CPSS&ECSC, 1998). Also the credit support deed under the English law is structured as a pledge.

To create and perfect a pledge requires usually more formality than the use of a title transfer (ISDA, 1998). This might include for example registration, filing or some other notification of the pledge. These formalities are needed to confirm the validity of the pledge and also to

guarantee a protection over third party claims, i.e. to perfect the pledge (ISDA, 1998; EFMLG, 2000). Also the form of the pledge may be regulated, e.g. it must be in writing (EFMLG, 2000). One significant shortcoming of a pledge is that the receiver of collateral cannot use the collateral in any other case than in default. The pledge document usually assigns some restrictions on the collateral taker and thus the taker has only a partial interest in the collateral (ISDA, 1998).

Title transfer

Another form of collateral arrangement is a title transfer. If the collateral is structured as a title transfer, all the rights to the collateral security are transferred to the collateral receiver (ISDA, 1998). The transferee then has an obligation to return the equivalent securities on the maturity if no default has occurred (CPSS&ECSC, 1998). The collateral provider also grants the collateral taker the right to net or set off the receiver's net exposure to the provider against the value of the securities or cash in the event of default by the collateral giver (ISDA, 1998).

The advantage of using the title transfer is that no formalities need to be established (ISDA, 1998). Thus using title transfer may be simpler and more straightforward compared to a pledge. It enables the collateral receiver to freely deal with the collateral and the collateral taker receives all the beneficial rights, such as for example the voting rights. Negative aspects of the use of a title transfer are for example its unenforceability in many jurisdictions, i.e. netting or set-off is not permitted or a title transfer is simply not recognized, its re-characterisation as a form of a pledge in some jurisdictions and its non-usability in US (ISDA, 1998).

3.3 Collateral amount determination

The decision, which the firm operating in the financial market has to make, is about the amount of the unsecured credit risk it is ready to face if it is willing to protect itself from the credit risk. When designing the collateral agreements, this exposure has to be taken into account, as the agreement determines the aspects affecting collateral amount. There are several different parts to be taken into account when calculating collateral delivery and return amounts. These are the haircut applied to the collateral value based on collateral riskiness, and the threshold amount, independent amount and minimum transfer amount that affect the collateral requirement amount based on counterparty riskiness. These parts are defined and

determined explicitly in ISDA credit support annexes. The parts are shortly presented in this chapter.

3.3.1 Haircut

Haircuts are applied to collaterals to protect against losses due to the price volatility of the collateral instrument. The haircut is a discount applied relative to the current market value when calculating the value of collateral. Thus, it is the difference between the current market value of an instrument and its value when used as collateral. Haircuts are subject to negotiation. Usually it is expressed as a percentage and it should be determined from the potential value change, i.e. the quality, of the collateral. Thus the haircut is different for different collateral instruments. (CGFS, 2001; CPSS&ECSC, 1998)

Basel II introduces haircuts in the comprehensive approach to collaterals and provides the ways in which they should be determined. Three different haircuts are introduced; haircuts reflecting collateral volatility, exposure volatility and currency mismatch. There are two ways in which haircuts can be calculated according to Basel II. Either the bank applies standard supervisory haircuts to the collaterals under the standard approach or it estimates the collateral volatilities itself under the own estimates approach. Under the standard supervisory approach haircuts range from 0,5% for sovereigns that are rated AAA or AA and has a maturity of less than one year to 25% for equities listed on a recognised exchange[16]. Banks may also be permitted to use their own estimates of haircuts subject to satisfaction of certain qualitative and quantitative standards. Key parameters of both of these haircuts are 99% confidence level and 5 to 20-business-day holding period. For capital market driven transactions, such as OTC derivatives transactions, 10-business-day holding period is assumed, if daily marking to market and remargining are conducted. Otherwise, if marking-to-market and remargining are conducted less frequently, larger haircuts are required, which are calculated using 'square root of time' –formula

$$H = H_M \sqrt{\frac{N_R + (T_M - 1)}{T_M}} \qquad (1)$$

where

H=haircut;

[16] See Appendix A for the whole table of standard supervisory haircuts

H_M= haircut under the minimum holding period;

T_M=minimum holding period for the type of transaction (10 for OTC derivatives)

and

N_R=actual number of days between remargining. (BCBS, 2001b; BCBS, 2003)

3.3.2 Threshold amount (TA)

This amount reflects the amount of credit risk the counterparty is willing to accept without any collateral. Thresholds are usually set according to the credit rating of the counterparty; the higher the rating the higher the threshold. The threshold also changes according to the changes in credit rating. The threshold amount is determined in the collateral agreement and it does not have to be the same for both counterparties. If the collateral agreement between the counterparties does not determine the threshold amount, it is usually assumed to be zero. The trend is currently towards zero thresholds irrespective of the credit rating of the counterparty. (CPSS&ECSC, 1998; CGFS, 2001; ISDA, 1998)

3.3.3 Independent amount (IA)

Sometimes a counterparty is required to post collateral even though the other counterparty has no current exposure. This amount is also known as *initial margin*. This may be a transaction specific or counterparty specific amount, which adds to the exposure. Usually, it is determined according to counterparty's credit rating. The independent amount serves as a buffer against the volatility of the underlying derivatives position between determining and receiving or liquidating the collateral, or between infrequent collateral calls. It also serves as a buffer against increasing counterparty risk, e.g. in the event of rating downgrading. (CPSS&ECSC, 1998; CGFS, 2001; ISDA, 1998)

3.3.4 Minimum transfer amount (MTA)

This amount is the minimum amount of collateral the counterparty needs to transfer to another counterparty. Only if the delivery or return amount of collateral exceeds the minimum transfer amount, collateral has to be transferred. Below this amount no collateral needs to be transferred, even though the calculations would indicate otherwise. Also this amount takes into account the quality of the counterparty; the higher the quality the higher the minimum transfer amount and the less frequent are the collateral transfers. On the other hand, the potential credit exposure increases as the minimum transfer amount increases, as no collateral

is received even though the exposure would indicate so. Also this amount can be asymmetric between counterparties. (CPSS&ECSC, 1998; CGFS, 2001; ISDA, 1998)

3.3.5 Collateral delivery and return amount

The following two figures, Figure 2a and 2b, illustrate the way collateral requirements are determined. The collateral on hand and the net exposure related to the underlying transaction are compared. If the net exposure exceeds collateral amount, more collateral has to be delivered. If collateral amount exceeds the exposure, excess collateral is returned. But before comparing these amount both has to be adjusted. The adjusted net exposure is determined by first calculating the net termination amount, i.e. the net exposure[17], and then adding independent amount applicable to the collateral giver and subtracting independent amount applicable to collateral receiver from the net exposure. Finally, a threshold applicable to the collateral giver is subtracted from this amount. If these calculations yield a negative number, the collateral requirement is deemed to be zero. The adjusted collateral is calculated by first discounting the collateral by a proper haircut, then converting the bid price to the base currency, and finally adding delivery amounts that have not been delivered but are due on or after the valuation day and subtracting return amounts that have not been returned but are due on or after valuation day. (ISDA, 1998; CPSS&ECSC, 1998))

Figure 2a Collateral delivery amount determination

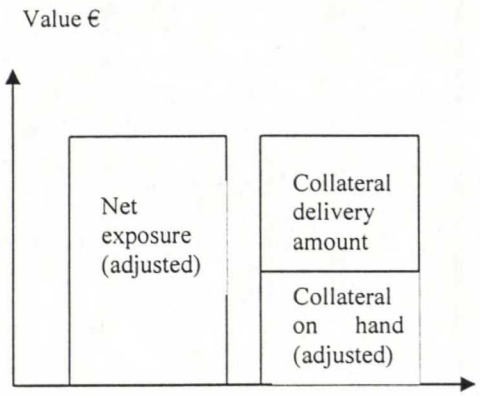
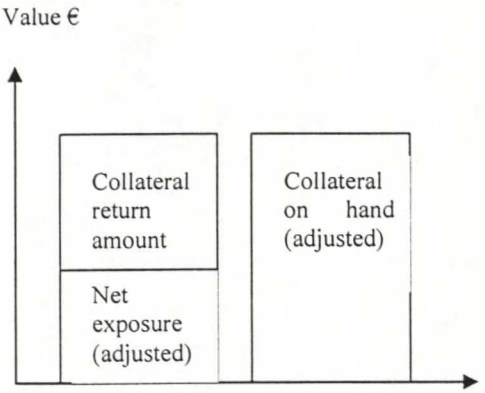


Figure 2b Collateral return amount determination



[17] This is the amount that one of the counterparties would be required to pay if all of the covered transactions would be terminated simultaneously and the termination payment would be determined according to the close-out netting provisions in the master agreement, i.e. the agreement governing the OTC derivatives transaction. (CPSS&ECSC, 1998)

4 Previous research

Previous academic research on collaterals has mainly focused on the studies of collateral usage in credit markets with imperfect information, thus emphasizing the motivation for using collaterals. International organisations and trade associations have conducted another field of study focusing on the current market situation and market practises of collateral usage. Their focus has been on OTC derivatives markets, but they also approach collateral usage more generally. These organisations have also released some guidelines and recommendations concerning collateral use. Vast amount of studies have explored the credit risk pricing of derivatives and especially interest rate swaps, but very few studies have been conducted which take into account the effect of collateralisation. Models aimed at measuring potential loss resulting from credit risk (VaR –models) have also been formulated, but again without taking into account collaterals properly. And most importantly, although recognized in some topical studies, there are very few studies focusing explicitly on risks related to collateral usage.

4.1 Collateral research in credit markets

Most of the earlier studies related to collateral usage are from the field of credit markets and credit rationing under imperfect information. These papers focus mostly on the rationale for using collaterals and also on the effects of collateral usage in credit markets. These studies provide the basis for understanding the logic for using collaterals.

Stiglitz and Weiss (1981) study credit rationing in credit markets with imperfect information and the role of the collateral in credit rationing. They provide the first theoretical justification for credit rationing and outline a model to study the use of collateral as a rationing device. They conclude that collateral requirements might have adverse selection and moral hazard effects in credit markets. This means that if the collateral requirements are increased or, in the first place, introduced (or equivalently interest rate is increased), either the safer borrowers are discouraged and they exit from the market or the riskiness of the funded risk adverse borrowers increases. This is because the borrower will adversely engage in more risky projects, thus resulting in adverse effect on the bank's loan portfolio's riskiness as well. Bank's profits are hence reduced, collaterals are not used as credit rationing device to eliminate excess demand and credit rationing equilibrium persists. Their main conclusion is thus that increasing collateral requirements causes adverse incentive and signalling effects.

Wette (1983) further investigates the role of the collateral in the credit markets when the credit rationing exists. She complements the study of Stiglitz and Weiss (1981) using their model and proves that also the risk neutral borrowers will act the same way as risk averse borrowers in credit rationing situations. The adverse selection effect occurs also among risk neutral borrowers decreasing lender's profits and again the collateral requirement is not a preferred way of eliminating excess demand.

Bester (1985, 1987) studies also screening and rationing in credit markets with imperfect information, but comes to different conclusions than his predecessors. He places the screening and incentive, and rationing devices against each other and concludes that no credit rationing, i.e. no borrower will be denied credit, will occur in equilibrium if banks use collaterals (and interest rates) as screening devices of borrowers' riskiness. He assumes that banks decide on both collaterals and interest rates simultaneously (two informative instruments jointly) and thus different contracts can be used as self-selection mechanisms. In his 1987 paper Bester explains the use of collateral as an alternative mechanism to credit rationing to respond to adverse selection and moral hazard behaviour. Lenders may use collaterals as a self-selection and incentive mechanism. He finds that less risky investors will reveal themselves by accepting higher collateral requirements and that collaterals work as an incentive mechanism for borrowers to engage in less risky projects. This result is in contrast with the earlier study of Stiglitz and Weiss (1981).

Boot, Thakor and Udell (1991) approach the collateral usage from additional perspectives. They study the conditions under which there is a relationship between borrower riskiness and collateral, they examine the relationship between collaterals and moral hazard empirically and they take into consideration also private information and its effects. They show that collateral is a powerful tool for dealing with moral hazard and they explain why collateral usage is widespread despite costs associated with collateral. Their main conclusion is that higher collateral may be posted by either safer or riskier borrowers, due to private information.

Also Coco (2000) studies the use of collateral and tries to find explanations for the massive use of collaterals in relation to debt contracts. He also concludes that collaterals may be used as screening or incentive devices and he argues that empirical evidence is consistent with the explanations that are based on the incentive properties of collaterals and on asymmetric

evaluation of projects between lenders and borrowers. Coco also finds that collaterals may eliminate credit rationing in some circumstances, as did Bester (1987).

4.2 Collateral research by international organisations

Two international organisations, International Swaps and Derivatives Association Inc., ISDA, and Bank for International Settlements, BIS, have conducted most of the topical collateral research. The research of these two organisations has mainly focused on the collateral as a risk mitigation technique, on the current situation of the collateral usage and on the trends and problems related to collateral usage.

ISDA has published every year since 1999 a collateral review, named Margin Survey, which focuses on quantifying and describing collateral assets used recently in the market, the extent of collateral use and the characteristics of collateral programs, mainly in OTC derivatives markets. The most recent one is from year 2003 (ISDA, 2003). ISDA has also published extensive guidelines of collateral usage for collateral practitioners (ISDA, 1998). The guidelines emphasize a collateralised relationship between two market participants and give advice on how to structure, implement and maintain a collateralised relationship. These surveys and guidelines are descriptive and consultative by nature and thus they serve the purpose of describing the current extent and importance of collateral usage.

BIS publishes annual reports, quarterly reviews, committee publications, working papers etc. on issues related to central banks, international banking and securities markets, and also special reports on the focus areas of certain committees. Relevant to collateral usage are the various publications of different committees. For example, Committee on Payment and Settlement Systems (CPSS) and the Euro Currency Standing Committee (ECSC) have published an extensive report on OTC derivatives and their current settlement procedures and counterparty risk management prepared based on interviews of 30 leading dealers in OTC derivatives markets (CPSS&ECSC, 1998). In their paper, the committees emphasize the risks associated with OTC derivatives transactions and the techniques used to mitigate these risks, especially the counterparty risk. Three key issues are highlighted, of which one is the expanding use of collaterals. Similarly, Committee on the Global Financial System (CGFS) has published an article about collateral usage in wholesale financial markets (CGFS, 2001). This paper, instead, focuses on the collateralisation as a trend in general and recognises the benefits and costs related to collateralisation. It explains the three most important areas of

collateral usage, of which one is OTC derivatives. Both of these papers thus provide general information about collateral usage in OTC derivatives market, but again are not academic research on the subject.

4.3 Collaterals in credit pricing and credit VaR models

Derivatives pricing models in general try to price the credit risk inherent in derivatives transactions. Both closed-form and reduced-form solutions are presented with various modifications, but the presence of collaterals as a risk mitigation technique has mostly been ignored. Only a few studies have attempted to incorporate collaterals into pricing models. Also some value-at-risk models have been created to evaluate potential losses due to credit risk, but they are not usually well suitable for e.g. swaps and do not take into account the effect of collateralisation.

4.3.1 Pricing derivatives subject to credit risk

Traditionally, pricing derivative securities involving credit risk has been based on the view that derivatives are contingent claims on the assets underlying the financial securities (e.g. Merton, 1974). Default by a counterparty is determined via the evolution of firm's assets, i.e. endogenously. In the simplest case, default occurs when firm's value is lower than the value of its obligations. This approach is the so-called closed-form solution and has not been proven very effective in practice. The problems related to the model arise also when trying to price OTC derivatives, e.g. swaps. Many have, however, followed or extended Merton's approach. One more recent example of this approach in the field of derivatives is the model presented by Cooper and Mello (1991). They study one-sided default risk of swaps and as a result they obtain a closed-form solution for the value of the default risk in the swap. They do not, however, take into account collaterals, but acknowledge that their model could be extended to include collaterals.

Another approach to model credit risk is the so-called reduced-form approach. Amongst the first ones to introduce the approach were Jarrow and Turnbull (1995). They base their work on their earlier paper where stochastic term structure of default-free interest rates and stochastic maturity specific credit-risk spread are taken as given. The approach views the risky debt as paying off an exogenously determined fraction of each promised dollar in the event of default, and also the time of default is given as an exogenous process. The default is not conditioned on the firm value. In their 1995 paper, Jarrow and Turnbull develop a new

methodology for pricing and hedging derivative securities involving credit risk. They apply the methodology to corporate debt, but the model can be used for derivatives, like swaps, as well. Also e.g. Duffie and Singleton (1994), Duffie and Huang (1996), Jarrow, Lando and Turnbull (1997), Cossin and Pirotte (1997) and Jarrow and Yu (2001) present similar reduced-form models with certain modifications. None of them, however, take possible collaterals into account.

Although vast amount of research has been done in the field of pricing derivatives with credit risk, very little attention has been paid to the impact of risky collateral used to mitigate credit risk. The presence of collateral in association with securities with credit risk has a complex effect and the effect cannot be analysed using traditional pricing models (Cossin and Hricko, 2001). To price an instrument collateralised with another risky instrument is not trivial and becomes even more complicated when marking- to-market or margin calls are added to the problem.

Cossin and Hricko (2001) are the first researches to take into account the effect of risky collateral when pricing claims with credit risk. They establish a theory of credit risk pricing with risky collateral and to do this, they analyse different stylised situations from a situation of simple non-stochastic collateral to a situation where both collateral and interest rates are stochastic and marking-to-market and margin calls are taken into account. They consider forward contract to illustrate the model. Their approach to pricing credit risk follows the Merton approach with classical contingent claims setting. Their work is a starting point to include collateral in credit risk framework.

Also Aparicio and Cossin (2001) have studied the impact of risky collateral on the pricing of credit risk. They apply optimal stopping and impulse control techniques and quasi-variational inequalities methodology in their study. They develop a general framework for the optimal control of credit risk collateralisation with situations of full and partial observation.

One study related to collaterals has also been conducted in Finland. Jokivuolle and Peura (2000) present a model for risky debt including stochastic collateral and take into account the correlation between collateral value and possibility of default. They apply the model to study the amount of debt that is expected to be recovered in the event of default as a function of collateral and to determine the amount of collateral that is needed to mitigate the credit risk of

a loan, i.e. the appropriate haircuts to be applied. They show that the recovery rate is a decreasing function of the collateral volatility and the correlation between the collateral and firm value. In contrast, the haircut should be an increasing function of the same factors. The model is only suitable for debt instruments. However, it takes into account the stochastic properties of collateral value and is a useful tool for determining haircuts for collaterals.

4.3.2 Credit value-at-risk models

Different banks and consultants have conducted most of the studies in this field. These value-at-risk, i.e. VaR- models measure the potential loss that can be suffered with a certain confidence level within a specified time horizon. These models include e.g. JP Morgan's CreditMetrics™, Credit Suisse Financial Products' CreditRisk+®, McKinsey's CreditportfolioView® and KMV's CreditPortfolioManager® (for more about the models, see e.g. Crouhy, Galai and Mark, 2000).

These models are all reduced-form models, assuming stochastic loss-given-default and exogenous recovery rate independent of default probability (Altman, Resti and Sironi, 2002). They assume deterministic interest rates and exposures, and are thus not appropriate for measuring credit risk in derivatives (Crouhy, Galai and Mark, 2000). In most of these models credit risk and market risk are analysed independently from each other, which is not suitable for derivatives instruments where these two risks are closely related. Thus, none of the current VaR- models provide an integrated approach to measuring credit risk e.g. in swaps. In addition, none of the models recognize collaterals.

4.4 Collateral risk research

Only a few previous papers have acknowledged the risks related to collateral usage. Even though the risks are indeed recognized in some papers, no extensive study of the risks in an organisational setting has been conducted. For example the report of the CGFS on the collateral use in wholesale financial markets recognises that using collaterals exposes the collateral receiver to market price, liquidity, operational and legal risks (CGFS, 2001). The paper focuses however only on the effective exposure, i.e. the potential loss given counterparty default, and on its determinants. The report of CPSS and ECSC considers the collateral risks more extensively and identifies the credit, liquidity, legal, operational, custody and systemic risks (CPSS&ECSC, 1998). The report explains in general the risks related to the collateral usage, but no empirical study or evidence is included. Its contribution to the

study of these risks is thus the acknowledgement of the risks. Hence, there exists no academic research on collateral risks.

5 Specific risks related to collateral usage in OTC derivatives markets

The rationale for the collateralisation is that it mitigates counterparty risk and transforms it into other kinds of risks. In other words, credit risk mitigation through the use of collateral involves the counterparties to collateralised transaction substituting other risks, including e.g. liquidity, operational and legal risks, for some, but not generally all, of the counterparty risk (CGFS, 2001). Collateral usage can also be described as turning original risks into a recovery risk and an asset value risk related to collateral instrument (Bessis, 1998). The two most important risks related to collateral usage especially in OTC derivatives markets are the counterparty risk left *after* collateralisation, i.e. the residual counterparty risk for the collateral receiver or the counterparty default risk for the collateral provider, and legal risk. Other relevant risks are liquidity risk, operational risk, custody risk, concentration risk and systemic risk. The risk categories and their relevant importances in this study were decided as a synthesis of existing collateral literature and research reports.

5.1 Counterparty risk

Counterparty risk related to OTC derivatives is usually defined as the replacement cost risk or pre-settlement risk, implying that in the event of a default by a counterparty the non-defaulting counterparty has to negotiate a new contract with a new counterparty thus incurring possible costs (CPSS&ECSC, 1998). Either party of the transaction could default. The counterparty risk related to OTC derivatives is much more complex than the traditional credit risk related to for example loans. In market-driven transactions, like OTC derivatives, in the event of default by the counterparty, loss is faced by the non-defaulting counterparty only if it is in-the-money, i.e. when the value of the swap is positive to the non-defaulting counterparty (see e.g. Hull, 2000). In-the-money means that the defaulting counterparty is owing money to the other counterparty. On the other hand, if the value of the contract is negative to the non-defaulting counterparty, i.e. it is out-of-the-money, in general there is no effect of the default on the non-defaulting counterparty.

To evaluate the counterparty risk related to collaterals in the context of interest rate swaps the following components need to be assessed: current and future potential exposure of the swap, the counterparty rating that affects the collateral requirement amount through different

amounts and the riskiness of the collateral instrument itself that affect the collateral requirement amount through haircuts. The traditional components of credit risk evaluation in addition to the exposures, namely probability of default by the counterparty and recovery rate as such are left out of the study, as the information is unnecessary. The probability of default by the counterparty is actually reflected in the credit rating of the counterparty and the recovery rate in turn is embedded in the collateral quality and riskiness. No traditional loss profiles are thus generated in this study.

5.1.1 Current and future potential exposure

Credit exposure is the amount of possible loss in the event of default by a counterparty (Dowd, 1998). If no collateral were used, the potential loss, i.e. *the current exposure* of a swap contract would be either the market value of the contracts (in-the–money) or zero (out-of-the-money). The market value of swap is usually the value of net interest payments, as no principal is exchanged, and the net credit exposure is thus only around 1 percent of the notional principal (Hentschel and Smith Jr., 1997). Figure 3a presents the swap counterparty exposure as a function of contract value. Note, that the exposure resembles the payoff function of a long call option. For the opposite counterparty the exposure is the mirror image of the graph, thus resembling payoff function of a long put option.

If, on the other hand, presented as a curve on a graph as a function of time (Figure 3b), the *future potential exposure* of an interest rate swap starts at zero at initiation, then increases and finally declines and decreases back to zero. This is because no principals are exchanged initially or at the end (Hull, 2000), and in between the netted cash flows that are exchanged create the exposure. Taking into account the deviations of the mark-to-market values in the future captures the future potential exposure (Bessis, 1998). There are as many future values, as there are possible values for market parameters at every future date. Thus the potential risk in the future, as an addition to the current risk measured by mark-to-market values, is actually dependent on the volatility of the swap value at each future date as the values are uncertain as of initiation of the swap. If the term structure of interest rates is assumed to be static over time, the graph of the future potential exposure would be a symmetric curve, such as in Graph 3b. In reality, however, term structures are not static and the exposure is more erratic. It should be thus noted that the current exposure of OTC derivatives may change very rapidly, since they are usually marked-to-market.

Figure 3a The current counterparty exposure of an interest rate swap as a function of no-default contract value

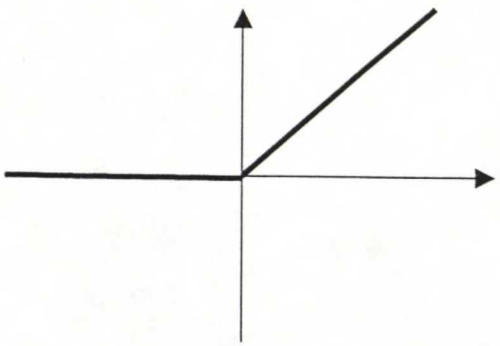
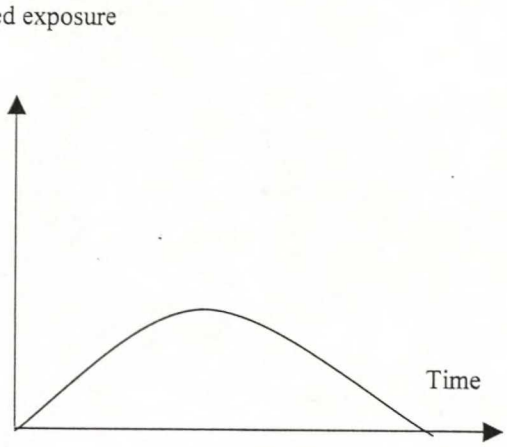


Figure 3b The expected future counterparty exposure of an interest rate swap as a function of time



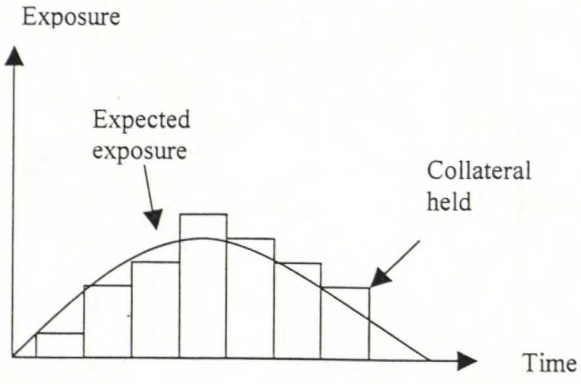
The effect of the collateral

Collaterals are used to reduce potential loss, i.e. to lower the exposure, in the event of default. When collaterals are used the exposure for the collateral receiver, i.e. the possible loss in the event of default by the counterparty, is the difference between the positive market value of the swap contract and market value of collateral, or zero (when collateral value exceeds swap contract value).

As mentioned, in addition to the rather straightforward current exposure valuation, future potential exposure needs to be evaluated, which is more complicated. In addition to the potential future value of the swap contract, the potential future value of collateral has to be taken into account. The future mark-to-market value of a swap can be easily determined by discounting the future swap cash flows by for example LIBOR zero-coupon interest rates (Hull, 2000), but potential exposure and the value of the collateral can be more difficult to assess, depending on the instrument used. Also the correlation between the collateral value and the swap contract value affect the future exposure (CPSS&ECSC, 1998).

To sum up the discussion of current and potential future exposures and collaterals, Figure 4 illustrates the effect of collateralisation on interest rate swap exposure value as a function of time.

Figure 4 The expected future counterparty exposure of an interest rates swap and collateral held



5.1.2 Counterparty rating

The rating and thus the quality and riskiness of the counterparty are directly reflected in the collateral required by the other counterparty (see e.g. CPSS&ECSC, 1998). There are three ways in which the quality of the counterparty affects the collateral requirement. First, the threshold amount (TA) applied to the counterparty is usually a direct consequence of the counterparty rating. The higher the rating, the higher the threshold. High thresholds increase the exposure faced by the collateral receiver. Secondly, the independent amount (IA), which serves as a buffer against adverse exposure movements, is again determined according to the counterparty's rating. The higher the rating is, the lower the independent amount applied. High independent amounts add to collateral requirement and reduce the exposure faced. And finally, the minimum transfer amount (MTA), which defines the minimum amount of collateral that the counterparty has to deliver or return, is also determined according to the counterparty rating. Here again, the higher the credit rating of the counterparty is, the higher is also the minimum transfer amount. High minimum transfer amount increases again the exposure. (See Chapter 3.3 for more details of these amounts)

5.1.3 Collateral instrument riskiness

The expansion of the range of possible collateral instruments increases the riskiness of the collateral instrument base. The expansion is due to both wider acceptance of instruments and scarcity of preferred instruments (see Chapters 2.2.1 and 2.4.2). This increased riskiness affects the collateral value, which in turn affects the effective exposure, i.e. the real exposure taking into account the possibility of insufficient collateral (CGFS, 2001). If the riskiness of the collateral increases, it is more likely that it will be insufficient to cover the underlying

exposure. The riskiness can increase either by increased riskiness of the collateral in use or by change of collateral instrument into a riskier instrument.

The way in which the riskiness and quality of the collateral instrument affects the collateral requirement amount is the haircut applied (ISDA, 1999). The higher the risk of the collateral is, the higher the haircut and thus higher the collateral requirement. Usually, the haircuts are directly attached to the collateral instrument based on their rating, issuer and residual maturity (e.g. the standard supervisory haircuts provided by Basel II).

Contributors to the collateral riskiness are

- price volatility of the collateral;
- liquidity of the collateral;
- credit quality of the collateral issuer;
- possible negative correlation between the collateral and the underlying exposure; and
- possible positive correlation between the collateral and creditworthiness of the collateral giver. (see e.g. ISDA, 1999; CGFS, 2001)

Volatility, liquidity and issuer credit quality

Volatility, liquidity and the issuer credit quality of the collateral are affected by the collateral instrument choice. As for example private issues are increasing, the liquidity of the collateral is lower and the volatility is higher compared to for example government securities when these instruments are increasingly used as collaterals. Also the credit quality of the issuer may be lower, as the issuer might be for example a corporation struggling with liquidity problems. When the volatility of a collateral increases the collateral position may change more abruptly and more significantly. Lower liquidity, on the other hand, implies lower liquidation gains to cover the underlying exposures in the event of default. Liquidity also affects the availability of the collateral instrument and thus the timeliness and accuracy of the collateral delivery. In addition, low credit rating of the collateral issuer implies increased default probability and thus possibility of losing collateral value.

Correlation with underlying position and counterparty's creditworthiness

If the price of the collateral instrument and the underlying position are negatively correlated, the value of the collateral decreases when the value of the underlying position increases and vice versa. This contributes to the insufficiency of the collateral to cover the exposure. This

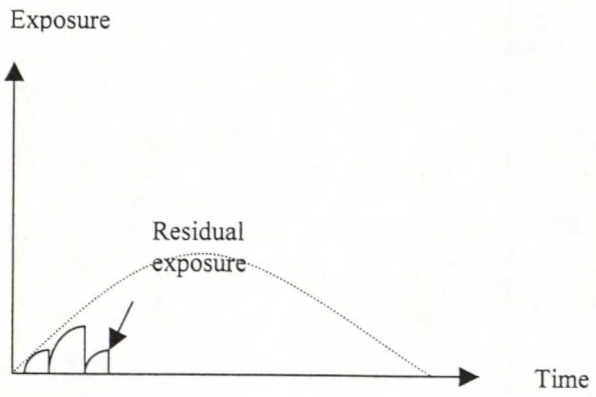
correlation might occur between instruments that are for example dependent on certain macro factors, such as interest rates, in very different ways.

If positive correlation exists between collateral value and counterparty's creditworthiness it implies that if collateral giver's creditworthiness declines for some reason, also the collateral value may decrease thus increasing the possibility for insufficient collateral and liquidity pressures faced by the collateral taker. For example instruments issued by the collateral giver used as collaterals are strongly correlated with the counterparty and it's creditworthiness. Such a correlation will again lead to insufficient collateralisation. Also other kinds of positive correlations with the collateral giver could exist and lead to the same.

5.1.4 Residual counterparty risk related to collaterals

The counterparty risk related to collateral usage, especially the risk for the collateral receiver, arises from the fact that the collateral may turn out to be insufficient to fully cover the exposure (as seen in Figure 5 as residual exposure; compare to Figure 4). The loss is faced when the collateral receiver is in-the-money, the other counterparty defaults in its payments and the collateral is insufficient to fully cover the in-the-money exposure.

Figure 5 Residual counterparty exposure of an interest rate swap as a result of insufficient collateralisation



This potential for loss given counterparty default, called *effective exposure,* which goes beyond traditional exposure calculations, depends on three aspects: value of the collateral instrument, value of the collateralised position and the effective exposure period (CGFS, 2001). First, non-cash collaterals are usually affected by changes in market prices and thus the collateral value may change over time. For certain instruments, such as government bonds, price volatility is quite low, but it tends to be higher for other fixed income securities. Second,

in derivatives markets, fluctuations in the market value of transactions may be quite large even within one day, thus changing the collateralised position rapidly. Third, the effective exposure period is the time lag between recognising the need for new collateral call and the actual fulfilment of the call. During this time exposure can change significantly. In addition, correlations between the collateral and the collateralised counterparty, in one hand, and the collateral and the underlying exposure, on the other hand, affect the effective exposure.

The collateral provider might also be exposed to a loss. This happens when the collateral receiver defaults. The collateral provider (the non-defaulting counterparty) might face an exposure in this case even if the swap contract is out-of-the-money, which alters the traditional swap counterparty risk evaluation significantly. This exposure arises when the non-defaulting counterparty has posted collateral and collateral giver is unable to recover the posted collateral from the defaulting counterparty, i.e. the collateral receiver (CPSS&ECSC, 1998). Especially, the collateral provider might be exposed to a risk of *overcollateralisation*[18]. More collateral is posted than is necessary and thus the collateral provider faces counterparty risk. When, according to the agreement between the counterparties in the case of default, the collateral provider closes out the contracts and offsets the amount owed to it with the collateral value, it faces loss, as the collateral value is higher than the underlying exposure, i.e. the amount owed to it, and all of it cannot be recovered (CPSS&ECSC, 1998).

5.2 Legal risk

The primary legal risk related to collateral usage is that the collateral arrangement will not be enforceable (see e.g. Bessis, 1998; Dowd, 1998; CPSS&ECSC, 1998). This risk arises from the problem of having sufficient legal rights to the collateral under the laws of all relevant jurisdictions. In OTC derivatives markets, where the markets are less regulated and standardised, the need for legal relations to be clear and regulated is critical. This form of risk is especially important in the case of default, when the debtors of the defaulting company might claim the collateral posted by it to be invalid or ineffective. Legal uncertainty might hinder the efficient use of collaterals and limit the business. Both of the counterparties to the collateral agreement face this risk irrespective of whether they both or only one of them posts collateral.

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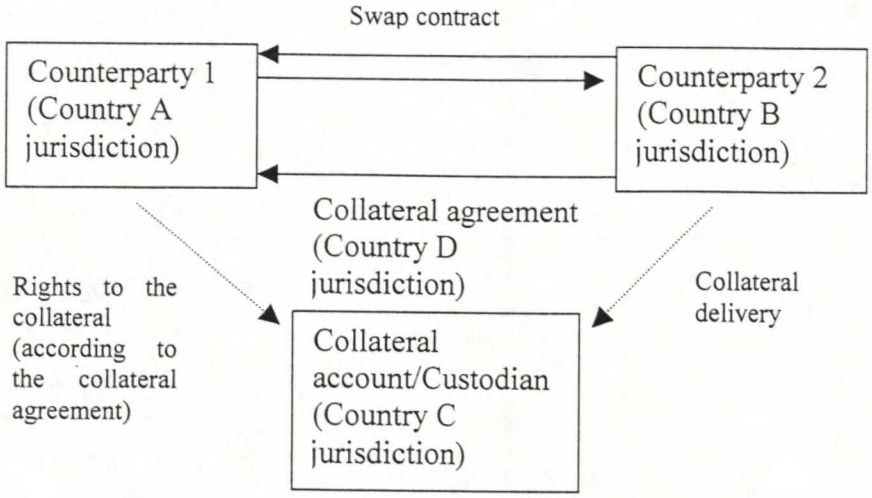
[18] In some cases, however, overcollateralisation may be caused purposely to achieve as perfect collateralisation as possible. Overcollateralisation is in theory the same procedure as imposing haircuts or initial margins to the collateral; both provide some cushion of extra collateral value beyond the actual marked-to-market value of the exposure (see e.g. ISDA, 1999).

There are several relevant jurisdictions that apply to the collateral arrangement when dealing with cross border counterparties. To evaluate the legal risk involves a thorough investigation of all relevant jurisdictions and their approaches to certain issues related to collateral usage. Figure 6 exhibits all of the relevant jurisdictions to be taken into account in one collateral agreement.

Figure 6 Different jurisdictions affecting one collateral arrangement related to an interest rate swap



The jurisdictions affecting the collateral arrangement are:

- jurisdiction of the collateral receiver (law of Country A);
- jurisdiction of the collateral provider (law of Country B);
- jurisdiction of the location of the collateral (law of Country C); and
- law governing the collateral agreement (English, New York, Japan or some national law).

It is increasingly difficult to be aware of all of the laws governing the collateral transactions, as the cross-border use of securities is growing rapidly (ISDA, 2000). Also, securities mainly exist and are more and more transferred and pledged in book-entry form. The main differences across relevant national jurisdictions, which need to be evaluated carefully, exist in three areas of legislation, namely in perfection requirements and enforcement of collateral agreement and collateral itself, the interpretation of the *lex rei sitae* rule and location of securities, and bankruptcy legislation (Thieffry and Bridson, 2000). There are of course differences between jurisdictions also related to for example collateral receiver's right to reuse collateral, recharacterisation of title transfer and enforceability of close-out netting and contractual set-off. These will, however, not be dealt with in this paper. It should also be

noted, that the form of the collateral transfer, i.e. pledge versus title transfer, affects the legal risk significantly.

5.2.1 Perfection requirements and enforcement of collateral agreements (lex contractus) and collateral arrangements

The law applicable to the collateral agreement usually governs the perfection requirements of collateral agreements, i.e. the contracts, and the enforceability of the collateral agreement. The law applicable can be either English, New York or Japan law, depending on the CSA used (see e.g. ISDA, 1998). In addition, if ISDA standard documentation is not used, all possible national legislations apply to perfection requirements and enforceability of the agreement.

Perfection requirements of collateral arrangements themselves include the formal procedures needed to ensure the collateral taker's rights to the collateral. Enforceability refers to the protection of the collateral against third parties and to the right to liquidate the collateral in default. The enforceability depends on the successful perfection of the collateral. The laws applying to the collateral agreements do not cover these two aspects. Instead, various law regimes can become relevant. In some jurisdictions, burdensome formalities might be required to perfect and enforce the collateral, in other jurisdictions no special procedures are needed. Thus the risk arises from the fact that the perfection and enforcement requirements may be cumbersome and difficult to fulfil in some jurisdictions or the law according to which these requirements should be fulfilled is uncertain. (Contact Group of the Legal and Institutional Underpinnings of the International Financial System, 2002)

5.2.2 The 'lex rei sitae' rule and location of securities

According to the *lex rei sitae* rule, the law of the country where the collateral securities are located governs usually the perfection and enforcement of the collateral receiver's right to the collateral (Thieffry and Bridson, 2000). Perfecting the collateral agreement is especially important when the form of the collateral transfer is pledge. The perfection requirements of pledges vary considerably among jurisdictions. For example in England, perfection requirements are quite burdensome (ISDA, 2000). Inability to comply with these requirements may lead to for example invalidity of the collateral. In contrast, the very nature of the title transfer, the transfer of the ownership to the collateral receiver, is part of the creation of the arrangement, and no special perfection requirements should be needed. In addition to perfecting the collateral, the collateral receiver needs also to be assured that the

collateral it has received is enforceable against third parties and, in the case of insolvency of the collateral provider, is free from third party claims and stays and it can be liquidated in favour of the collateral receiver. This might also require some burdensome formalities.

Usually the law of the country where the collateral is located is applied to the creation of a security interest, i.e. pledge, and to the perfection requirements. However, in the modern cross border multi-tiered securities holding system, where securities mainly exist and are transferred and pledged in book-entry form with long ownership chains, no clear rule exist as to what constitutes the lex rei sitae for these interests (Thieffry and Bridson, 2000). Thus it is extremely difficult for the participants in the modern markets to ascertain which law to apply to collaterals.

Thus, the risk arises from the difficulty of determining the location of the collateral and thus the law that should be applied to perfection and enforcement is unclear. Different jurisdictions have different ways to determine the location and might end up with different solutions. E.g. for dematerialised or registered securities the lex rei sitae can be either the law of the issuer's place of organisation or the law of the jurisdiction where the issuer's securities' records are maintained (Thieffry and Bridson, 2000). But in modern markets, where there is no physical possession or records of ownership, the lex rei sitae is difficult to apply, as there is no consensus on the location of the collateral. One solution to the problem is the lex rei sitae rule applied in the EU Directive on Settlement Finality (article 9(2)) and in EU Directive on Financial Collateral Arrangements (article 9), or the PRIMA rule followed in Hague convention (see Chapters 3.1.2. and 3.1.3. for more details).

5.2.3 Bankruptcy legislation (lex concursus)

The law of the residence country of the insolvent counterparty is usually applied to the insolvency proceedings (Thieffry and Bridson, 2000). Hence, in the case of insolvency any possible national law can be the applicable law. If the insolvent counterparty has offices in many countries, there can be insolvency proceedings in many jurisdictions.

The purpose of the insolvency legislation is the same in every jurisdiction, namely to ensure that all creditors are treated fairly. However, there are differences between jurisdictions concerning certain aspects. When clarifying the relevant insolvency jurisdictions, it should be considered whether the pledged collateral could be liquidated quickly or whether it would be

a subject of stay and whether the collateral needs to be shared with other creditors, and how the so called top-up collateral[19] is treated.

In some jurisdictions, collateral assets are subject to a certain stay period during insolvency or restructuring proceedings of the collateral giver (ISDA, 2000). During this period, the collateral taker cannot enforce collaterals. This worsens the collateral takers standing, as it cannot liquidate the collateral to cover possible losses due to counterparty insolvency. There are also certain sharing rules in some jurisdictions, especially in the case of a title transfers, that call for sharing of the collateralised assets with other creditors of the insolvent counterparty (ISDA, 2000). This means that third party rights might disrupt the netting or set-off between counterparties during insolvency. This might happen if the collateral giver has not perfected the collateral properly or simply by operation of law.

There are also different ways to treat the so-called top-up collateral in different jurisdictions in the event of default. In some jurisdictions the top-up collateral delivered within certain period before the start of the insolvency proceedings will be declared invalid or ineffective, thus requiring return of the collateral to the insolvent counterparty without any set-off or deduction against the exposure. Other jurisdictions, on the other hand, have certain protective regulations that declare the equivalent collateral valid and enforceable. (Contact Group of the Legal and Institutional Underpinnings of the International Financial System, 2002)

5.3 Other risks

5.3.1 Liquidity risk

Liquidity risk for both counterparties to collateralised OTC derivatives transactions arises from the collateral calls. Top-up collateral needs to be offered when collateral value declines or value of the underlying transaction increases. These calls might be as frequent as daily, causing liquidity pressures. The ability to meet these calls depends largely on the counterparty's business and the underlying collateral agreement. Market participants might even be forced to liquidate assets or borrow cash to meet these liquidity pressures. When rehypothecation, i.e. reuse, of collateral is allowed, collateral takers are better able to meet

[19] The top-up collateral implies the additional amount of collateral that the counterparty has to post or return when it has already posted some amount of collateral. It is the difference between the posted collateral value and the exposure value. This is thus the normal delivery or return amount determined by the normal collateral calculation procedures at every valuation day.

collateral calls. Especially credit rating downgradings impose additional collateral demands. (CGFS, 2001; CPSS&ECSC, 1998)

Liquidity risk refers also to the problem of being able to liquidate the collateral in case of default and with a sufficiently good price. In addition, the liquidity risk in the context of collaterals refers to the ability to acquire certain types of collaterals. This implies that when for example a relatively rarely traded corporate bond is required as collateral, there might exist some problems when trying to acquire the bond. However, these forms of liquidity risk are treated in connection with the riskiness of the collateral instruments, i.e. under the collateral instrument riskiness.

5.3.2 Operational risk

Operational risks are any risks related to operational issues; they can be related to either humans, communications, models or they can be for example breakdowns of systems, computers or other technical devices (Dowd, 1998). Each firm participating to collateralised transaction is exposed to operational risk (ISDA, 1998). Management of collateral agreements causes these operational risks. Using collaterals requires building up proper systems and internal controls. Collaterals require frequent revaluation, and substitutions and rehypothecation of collaterals adds to operational requirements. Operational risks arise also for example from incomplete or missed collateral calls (ISDA, 1998).

5.3.3 Custody risk

Custody risk is the risk that the counterparty receiving collateral incurs losses due to insolvency, negligence or fraudulent action by the custodian who holds the received securities (CPSS&ECSC, 1998). Usually this risk is avoided by requiring the custodian to segregate the securities provided as collateral from its own assets. Also the collateral provider is affected by the fraudulent behaviour of the custodian, as it might be unable to recover the collateral from the custodian. The custodian also contributes to the legal risk related to collaterals as the jurisdiction of the custodian adds one more jurisdiction to be taken into account when determining lex rei sitae and other aspects of legal risk. Also potential custody system failures add to operational risk (ISDA, 1998)

5.3.4 Concentration risk

Concentration risk is a consequence of obtaining collaterals of the same type from various counterparties independently from each other and thus relying too heavily on one type of collateral or collateral issuer (ISDA, 1999). This leads to a situation where collateral taker must rely on one particular issuer or group of issuers, and on their instruments. Thus, in case of default or insolvency by the issuer or group of issuers, the collateral instruments might lose their value or even become worthless to the collateral taker.

5.3.5 Systemic risk

It has been recognized that the use of collaterals in inter-dealer transactions reduces counterparty risk, and thus also reduces the possibility of systemic disturbances spreading due to e.g. major global institution's failures. It has been noted, however, that the collateral usage entails other risks, as presented above, and these risks can materialise in some circumstances so that they pose threats to the whole financial system. For example, one unenforceable collateral agreement may lead to loss of reliance to these agreements in general. Or large collateral demands due to large price movements may lead to difficulties for the volatile markets to meet these calls. (CPSS&ECSC, 1998)

5.4 Collateral risk analysis

All of the risks related to collateral usage will be evaluated separately in this paper. The evaluation will emphasize the counterparty risk for both parties to the collateralised transaction, incorporating the changing risk profile of the collateral pool, and the emphasis will also be put on the legal risk. Both quantitative and qualitative methods will be used.

5.4.1 Qualitative analysis

All of the risks related to collateral usage are evaluated qualitatively. The objective of the qualitative study is to get a thorough and complete image of the collateral risks. In a way, the qualitative analysis forms the basis on which the quantitative analysis of the study can be built. This form of analysis helps to understand the factors and contributors of every risk category and to assess the importance of every risk class. Also some ways to reduce the risks are presented.

The risks are evaluated from the point of view of a financial institution for which the collateralisation is a new phenomenon. Thus the focus is limited on the early stages of the

collateralisation process. A summary of the risks and risk analysis will be provided at the end of the qualitative analysis to get a clear view of the total risk profile of collaterals. Risks are evaluated qualitatively in Chapter 7.

5.4.2 Quantitative analysis

Quantitative analysis is only applied to the counterparty risk evaluation. The evaluation involves first estimating the potential counterparty exposure of interest rate swap from a simulation of market risk factors. The underlying market risk factor for interest rate swap is clearly the term structure of interest rates. To model the term structure of interest rates Principal Component Analysis (PCA) is used (see e.g. Kreinin, Merkoulovitch, Rosen and Zerbs, 1998; Reimers and Zerbs, 1999; Hull, 2000). The potential exposure profiles are then simulated based on risk factors and future term structures using Monte Carlo simulation. The method is explained in more detail in the next chapter and in Appendix B.

Second, the required collateral amounts need to be evaluated similarly. In addition to the exposure value, counterparty rating and collateral instrument riskiness both affect the collateral requirement amount. The collateral amounts are defined as a combination of ISDA's and BIS's techniques to determine collateral delivery or return amount according to the riskiness of the counterparty and the riskiness of the collateral instrument (see e.g. ISDA, 1998; BCBS, 2001b; BCBS, 2003).

Further, differing imaginary counterparties are created. All of the counterparties have different ratings and thus their riskiness differ. These imaginary counterparties are evaluated to get an image of the effect the counterparty's riskiness has on the collateral amount determination and thus its sufficiency. This part involves an assessment of appropriateness of the collateral requirement determination amounts, i.e. threshold amount, independent amount and minimum transfer amount. The assessment is based on imaginary scenarios created based on counterparty ratings and amounts and assessment is done by CaR –analysis.

Similarly, different types of collateral instruments are chosen as the object of the study, and their sufficiency and contribution to remaining counterparty risk for both counterparties are evaluated. To incorporate the changing risk profile of the collateral pool into the study, various collateral instruments with differing risk profiles are examined. Especially their volatility and thus haircut appropriateness are evaluated. Their correlations with the exposure

are also evaluated. The study will start with a riskless collateral, namely cash, and proceed with instruments with increasing risk profile. Altogether four different instruments are used as sample collaterals. This part of the study is based on historical yield and price data of the instruments, and on simple volatility and correlation analysis. The results of the quantitative analysis are presented in Chapter 8.

6 Case, methodology and data

6.1 Case description

The qualitative and quantitative parts of the study are both based on an imaginary case study. To evaluate the sufficiency of certain amounts of collateral based on the volatility of an interest rate swap in which collateral is applied and on the collateral riskiness, an imaginary case interest rate swap is created. Accordingly, imaginary collateral instruments and collateralised counterparties are created.

6.1.1 Collateralised transaction

Although the swap is an imaginary one, it is designed to be such that it could exist in reality. The maturity of the swap is 5 years and the nominal amount is 100 000 000 €. The fixed interest rate is 3,073% per annum and the floating interest rate is three-month rate. The fixed rate is estimated so that the value of the interest rate swap is at par at initiation, i.e. it is chosen to be such that the value of both of the interest rate swap components (the fixed rate leg and the floating rate leg) equal the notional principal of the swap at initiation. The floating rate leg is at par every three months, implying that its value equals the nominal principal of the swap at every payment date (minus the present value of the principal). The swap is examined from the viewpoint of the floating rate payer, i.e. the fixed rate receiver. (The effective date of the swap and the first acquiring or delivery date of the collateral instrument is assumed to be June 2nd, 2003, as the historical data for the simulation reaches up to May 30th, 2003.)

6.1.2 Collateralised counterparties

Since the collateralisation of interest rate swap transactions is quite a new phenomenon, at least in Finnish financial markets, and not enough information is available, several imaginary collateralised counterparties are created to be able to assess the impact the counterparty's riskiness has on the required collateral. The collateralised counterparties are assumed to be other financial institutions, such as banks, with differing credit ratings, as most of the interest

rate swap deals are conducted between banks, brokers, insurance companies and hedge funds (ISDA, 2003; Chapter 2.2.3).

Four different counterparties are assumed; one institution rated AA[20] with a probability of default of 0,27% in five years, second institution rated A with a probability of default of 0,56% in five years, third institution rated BBB with probability of default of 2,19% in five years and the fourth institution rated BB with probability of 12,38% in five years. These probabilities of default describe the probability that the counterparty might default at any time between time zero and year five and thus indicate clearly their varying riskiness. This time period is chosen, as the maturity of the swap transaction is five years. The ratings of the counterparties range between AA and BB, which are common ratings to international banks and securities firms[21]. It is assumed that there is only one counterparty and one transaction at a time, although all of the counterparties are examined in turn. The portfolio with each of the counterparties consists of the same interest rate swap, implying that the counterparty exposures are the same for all counterparties. Also the collateral instruments used are the same with each of the counterparties. Both counterparties to the collateralised transaction use the same collateral instruments, as they are agreed to be eligible.

The riskiness of the counterparty is reflected in the collateral amount in three ways. The threshold (TA), independent (IA) and minimum transfer amounts (MTA) are subject to negotiation between the counterparties and there is no general rule on how to determine them. The amounts are not based on for example any exposure profile estimates. They are determined based solely on the counterparty's creditworthiness. These three amounts are evaluated under three different scenarios. The amounts are set to be such that they are as realistic as possible. Variations around the most likely threshold, independent and minimum transfer amounts, which are considered in the realistic scenario, are dealt with in the other two scenarios.

The counterparty, from whose point of view the swap agreement is examined, is assumed to be an A rated institution (this is the average rating for the counterparties responding to ISDA

[20] The ratings are Standard and Poor's ratings and the probabilities of default are based on historical cumulative default rates reported by Standard and Poor's.
[21] The ratings of the banks and financial institutions that responded to the ISDA Margin Survey 2003 range between AAA and BB-, with the most common rating of AA- or A+ (www.standardandpoors.com, www.isda.com).

Margin Survey 2003; see Footnote 21). The independent amount, the minimum transfer amount and the threshold amount are set to be equal with the counterparty having A rating in every scenario. These amounts could also be asymmetric between the counterparties, but to simplify the analysis, they are assumed to be same for counterparties rated at the same level.

Scenarios

In scenario 1, *the conservative scenario*, the thresholds are set to zero, independent of the credit rating, which is actually the current trend, the independent amounts are set to be quite conservative and the minimum transfer amounts are also set to zero, irrespective of the credit rating. Table 2 tabulates the counterparties and respective amounts under the first scenario.

Counterparty	*Conservative scenario*		
	TA	*IA*	*MTA*
AA	0€	3 000 000€	0€
A	0€	5 000 000€	0€
BBB	0€	10 000 000€	0€
BB	0€	15 000 000€	0€
The A inst.	0€	5 000 000€	0€

Table 2 Threshold amounts, independent amounts and minimum transfer amounts for each of the counterparties under the conservative scenario

Second, in scenario 2, *the realistic scenario,* certain thresholds and independent amounts are set, based on the credit ratings. Independent amounts are only set to counterparties under investment grade. Minimum transfer amounts exist in this scenario, and they also differ based on credit ratings. The details are in the Table 3.

Counterparty	*Realistic scenario*		
	TA	*IA*	*MTA*
AA	35 000 000€	0€	1 000 000€
A	15 000 000€	0€	800 000€
BBB	5 000 000€	10 000 000€	600 000€
BB	0€	10 000 000€	400 000€
The A inst.	15 000 000€	0€	800 000€

Table 3 Threshold amounts, independent amounts and minimum transfer amounts for each of the counterparties under the realistic scenario

Third, in scenario 3, *the 'trust' scenario*, the threshold amount is determined according to the counterparty's credit rating. In this case, the threshold amounts change quite radically among rating groups and no threshold is applied to the counterparty with lowest credit rating. No independent amounts are applied and minimum transfer amounts are rather high. The details are shown in Table 4.

Counterparty	*'Trust' scenario*		
	TA	*IA*	*MTA*
AA	50 000 000€	0€	10 000 000€
A	25 000 000€	0€	8 000 000€
BBB	5 000 000€	0€	6 000 000€
BB	0€	0€	4 000 000€
The A inst.	25 000 000€	0€	8 000 000€

Table 4 Threshold amounts, independent amounts and minimum transfer amounts for each of the counterparties under the 'trust' scenario

6.1.3 Collateral instruments

Collateral instruments are chosen to be such that they are recognized by the new Basel capital accord as eligible collateral. This is important, since in practice all banks are expected to follow the new capital adequacy framework in some form in the future if they want to receive allowances for capital requirements related to risk mitigation techniques. The instruments are chosen also to reflect the fact that collateral instrument pool riskiness is increasing. As government issues are declining, new instruments have to be taken into use. Nowadays the Basel II accepts indeed a wider range of collateral instruments than earlier. All of the collateral instruments are real and existing instruments used in the financial markets.

First, it is assumed that only cash is used as collateral. No haircuts are applied to cash[22]. The cash collateral is given in same currency as the underlying exposure, i.e. in Euros. Euro cash is one of the eligible collateral instruments recognised by Basel II and it is indeed extremely widely used as collateral.

Second, a relatively riskless bond collateral is used. The example bond used is a German government bond, a federal bond (*Bundesanleihen*). The German sovereign is rated at AAA (Standard and Poor's). The bond has a residual maturity of about 5,5 years. The bond was

[22] Haircuts are not applied to cash except when there is a currency mismatch between the collateral and the underlying exposure. This means that the currencies differ from one another. In that case a currency haircut would be applied.

issued in 1999, with an original maturity of 10 years (maturity date is January 4th, 2009) and it is denominated in Euros. Haircuts are applied to this instrument. The rating of the bond is the highest possible, namely AAA (Standard and Poor's). With these features, the collateral would be recognized by the new Basel accord, i.e. it is rated by an external credit rating agency and the rating is above BB- (see Chapter 2.2.1).

Third, a corporate bond is used as a collateral. Thus the riskiness of the collateral is increased further. The bond used is a corporate bond issued by StoraEnso Oyj, a Finnish forest industry company, with a credit rating of BBB+ (Standard and Poor's). The bond has a remaining time to maturity of about 3,5 years, thus there exists a maturity mismatch between the underlying exposure and the collateral. The bond was issued in 2000 with an original maturity of 7 years (maturity date is June 29th, 2007) and it is denominated in Euros. The bond is listed on Luxemburg Stock Exchange. Haircuts are again applied to this instrument. The example corporate bond has a rating of BBB+ (Standard and Poor's), which implies that it qualifies as eligible collateral recognised by Basel II (i.e. it has been rated by external credit rating agency and the rating is above BBB-).

Finally, equities are used as collateral instruments. They represent the instruments at the end of the range of preferred collaterals and are thus also the riskiest collaterals. The equities used as sample collateral are Nokia Oyj's equities. Nokia Oyj is rated at A (Standard and Poor's) . Because the example equities are included in main index, the HEX all share Index, and are traded on an exchange, Helsinki Exchanges, they receive a quite low haircut compared to other equities. However, the haircut is higher compared to other collateral instruments used. Equities that are included in main index are recognized by Basel II as eligible collateral. Also equities not included in main index, but traded on a recognized exchange, would be approved by Basel II as eligible collateral under the comprehensive approach.

The approach to collaterals taken in this study follows the comprehensive approach presented in Basel II under the standardised approach to credit risk (see Chapter 3.1.4.). It implies that haircuts are taken into account when determining collateral amounts. This approach is also the only approach applicable to trading book exposures, in which the OTC interest rate swaps usually include. The haircuts are calculated as increasing the exposure, and thus only after applying haircuts to the exposure the real collateral amount required is determined correctly. This approach allows also maturity mismatches, i.e. differences in maturities of the collateral

and the underlying, which in this case is necessary, as the remaining maturity of the corporate bond is shorter that the remaining maturity of the exposure. Standard supervisory haircuts provided by Basel II are applied (see Chapter 3.3.1 and Appendix A). Standard supervisory haircuts are, however, adjusted to reflect the real remargining period of the underlying instruments. This is done using the 'square root of time' -formula presented in Chapter 3.3.1. Different haircuts are applied to bonds during the interest rate swap agreement based on the remaining time to maturity of the collateral. Table 5 describes each of the four collateral instruments.

Collateral instrument	*Rating of the instrument*	*Rating of the issuer*	*Remaining time to maturity*	*Standard supervisory haircut*	*Adjusted haircut*
Cash	-	-	-	0%	0%
German government bond	AAA	AAA	> 5 years	4%	10,7%
			1-5 years	2%	5,4%
			< 1 year	0,5%	1,3%
StoraEnso Oyj corporate bond	BBB+	BBB+	1-5 years	6%	16,1%
			< 1 year	2%	5,4%
Nokia Oyj equities	Traded on exchange; included in main index	A	-	15%	40,2%

Table 5 Collateral instruments, their ratings and issuer ratings, remaining time to maturity, standard supervisory (BIS) haircuts and adjusted haircuts used in the study

6.1.4 Collateral custodian and relevant jurisdictions

The location of the counterparty has a special effect on the legal risk, but it plays only a minor role when assessing counterparty risk or other risks. However, it is assumed for the purpose of the legal risk analysis that the counterparties are located only in Great Britain and in Finland. This simplifies the analysis, as the English law is also one of the governing laws of the CSAs and the study is conducted from the viewpoint of a Finnish counterparty. Thus the number of law regimes that need to be analysed is kept to minimum.

However, one additional law regime has to be taken into account. That is the jurisdiction of the country where the collateral, i.e. in practice the custodian, is located. There are a number of different custodians that a financial institution operating with collaterals could choose. These are for example Clearstream Banking in Luxemburg, Euroclear in Belgium, JPMorgan

in several continents and Bank of New York in USA. Since the Euroclear bank is currently the biggest in Europe, most reliable and mostly used custodian for collateral instruments, it is taken as the sample custodian also in this study. It is also the most advanced in its collateral management function among the collateral management providers. As mentioned, Euroclear is located in Belgium, so the Belgium law is added to the analysis.

6.1.5 Collateral agreement

With each of the counterparties the ISDA CSA under the English law is used. Both title transfer and pledge CSA can be used. The choice of the contract has an effect on the legal risk faced. Under this agreement, threshold amounts, independent amounts and minimum transfer amounts applying to both counterparties are agreed. If no amount is stated, it is assumed to be zero. Similarly, the haircuts applied to the collateral instrument are agreed, based on the Basel II standard supervisory haircuts. The collateral agreement is a two-way agreement, implying that both of the counterparties are under obligation to provide collateral.

6.2 Methodology and models

The counterparty risk of the collaterals is evaluated in this study in two different ways. First, a model based Monte Carlo simulation is used to simulate swap values, in which CaR-analysis is applied to evaluate the volatility of the swap values and thus the sufficiency of threshold, independent and minimum threshold amount. The collateral instrument riskiness, on the other hand, especially the volatility and correlation with the underlying exposure and thus the appropriateness of applied haircuts are evaluated based on historical yield and price data and using simple volatility and correlation calculations.

6.2.1 Simulation model

The quantitative method used for the interest rate swap counterparty exposure determination is a model based Monte Carlo simulation, in which several scenarios are developed based on the market risk factors that affect the value of the interest rate swap. The market risk factor is the term structure of interest rates, as it determines the value and thus the counterparty exposure of an interest rate swap in the future. Because of the vast amount of the simulations that would be needed to correctly estimate the future term structures and because of the correlations inherent in the data, Principal Component Analysis (PCA) (see e.g. Hull, 2000; Reimers and Zerbs, 1999; Kreinin, Merkoulovitch, Rosen and Zerbs, 1998) is used to

decrease the amount of variables that need to be simulated and to avoid modelling the correlations.

The basic idea behind the PCA is to find reasonable amount of so-called risk factors that explain the term structure as well as possible, and that probably will also affect the future changes in the term structures. In other words, the risk factors explain the variability in the original data as much as possible. In the PCA, variables that are highly correlated are transformed into a number of uncorrelated factors. The risk factors are found with the help of the eigenvalues of the correlation matrix of the original data. In this case the term structures of interest rates are defined by two risk factors. These two risk factors are sufficient to explain the movements of term structures of interest rates. The first risk factor represents the parallel shift of the term structure curve and the second factor represents the twist of the curve. After finding the appropriate risk factors, new 'future' risk factors are simulated based on 'historical' risk factor values. The risk factors are assumed to follow Ornstein-Uhlenbeck – process (see e.g. Hull, 2000; Gibson, Lhabitant and Talay, 2001; Barndorff-Nielsen and Shephard, 2001), the parameters of this process are estimated and the random vector is simulated with Random Number Generator. After the simulation, risk factors are converted back to interest rates and further to discount factors that are used in the swap valuation. To understand the idea underlying the PCA, see Appendix B.

6.2.2 Swap valuation model

The Monte Carlo simulation model is based on a straightforward cash flow based valuation analysis, which underlies the basic interest rate swap valuation. The value of the interest rate swap is calculated as a combination of two bonds, one fixed rate bond and one floating rate bond. The value of the swap is

$$V = \left[r \sum_{i=1}^{M} d(0,i) - \left[1 - d(0,M)\right] \right] N \qquad (2)$$

where

r is the fixed rate;

N is the nominal principal;

M is time to maturity, i.e. the contract period;

$d(0,M)$ is the discount factor for the time to maturity and

$d(0,i)$ is the discount factor for each fixed payment (Luenberger, 1998)

The value of the fixed rate swap is calculated simply by discounting the future cash flows by appropriate discount factors (that are the result of the simulation) and then subtracting the accrued interest. The value of the floating rate bond is at par every three months implying that its value corresponds to the nominal principal of the swap every three months minus the present value of the nominal principal. The value of the swap is achieved thus simply by subtracting the adjusted nominal principal from the fixed rate bond value.

6.2.3 Collateral requirement determination model

The amount of the collateral required is calculated as determined by ISDA and presented in Chapter 3.3.5. It is defined by the following calculation:

Average exposure of the collateral receiver
+Independent amount of the collateral giver
-Independent amount of the collateral receiver
-Collateral giver's threshold
=Collateral requirement

After determining the collateral requirement the amount is compared to the collateral giver's minimum transfer amount and a proper BIS standard supervisory haircut is applied to discount the value of collateral instrument and to increase the requirement to protect against adverse price movements of the collateral instrument. This practice of viewing haircut as an addition to the exposure is applicable here, as there is only one exposure[23]. The application of the haircut can be seen as lowering the value of the collateral instrument or increasing the exposure amount. Thus the haircut increases the required collateral amount.

For example, the Finnish financial institution is requiring collateral from its A rated counterparty and the collateral used is the German government bond. There are only two years left of the contract, thus the time point is month 36. The collateral requirement under the realistic scenario would be as shown in Table 6.

[23] In practice, when there are several underlying exposures and collateral portfolios requiring differing haircuts, this practice would not necessarily be applicable.

Time point 36	Realistic scenario
A counterparty	€
Average exposure of the collateral receiver	93 305,24
+Independent amount of the collateral giver	5 000 000
-Independent amount of the collateral receiver	5 000 000
-Collateral giver's threshold	0
Collateral requirement	**93 305,24**
Minimum transfer amount of the giver	0
Collateral delivery amount	93 305,24
Haircut	0,1073
Real collateral delivery amount	**104 523,93**

Table 6 An example calculation of a collateral requirement

6.2.4 Assumptions and simplifications

The simulation of the term structures and thus the swap values is performed over the entire life of one interest rate swap transaction. Only the exposure profile resulting from the cash flow payments is examined and no loss calculations that take into account default probabilities of the counterparty or recovery rates are performed. The interest rate swap is valued, i.e. remargined, every three months, which complies with the minimum requirements set out by the Basel II. The swap is examined separately for every three month period assuming that the term structures will be realized as expected at time zero and thus the volatilities can be regarded as implied volatilities for each period. In reality, however, when time goes on, and one time point at a time is achieved, the value of the next month's expected exposure is uncertain, as is also the standard deviation.

It is assumed that once the threshold, independent and minimum transfer amounts have been negotiated and agreed between the counterparties, these amounts are not changed. The counterparty rating is assumed to remain constant throughout the five-year period and thus there is no need to adjust the amounts.

As the remaining time to maturity of the German government bond will decrease below 5 years and eventually below 1 year, and the remaining time to maturity of the StoraEnso Oyj corporate bond will decrease below 1 year during the swap agreement thus triggering change in haircut level, different haircuts are applied. There is however a maturity mismatch between the exposure and the StoraEnso Oyj bond. It is assumed that this bond collateral is just rolled out to a corresponding instrument when it matures. It is also assumed that the ratings of the collateral instruments or their issuers do not change during the five-year period. The haircut is applied only to the collateral instrument, as the collateral determination amounts are designed

to protect against adverse movements in the underlying exposure. Currency haircuts are not needed, as no currency mismatches exist.

6.3 Data

The historical data used for the estimation of the risk factors in the simulation are from the period of 28.2.1995-31.5.2003 and the data are extracted from Reuters. The data are monthly Euroswap offer interest rate data. The term structure is defined by 14 key rates (1 month, 3 months, 6 months, 9 months, 1 year, 2 years, 3 years, 4 years, 5 years, 6 years, 7 years, 8 years, 9 years and 10 years), or more precisely, 37 interest rate points. There are 100 observations in total.

The sample information to create the imaginary counterparties is gathered from ISDA, BIS and credit rating agencies (www.isda.org, www.bis.org, www.standardandpoors.com, www.moodys.com).

The information for the collateral instruments is extracted from stock exchanges, external credit rating agencies and company web pages (www.hexgroup.com, www.nyse.com, www.bundesbank.de, www.standardandpoors.com, www.storaenso.com and www.nokia.com). The historical time series data, on which the volatility and correlation estimations of each collateral instrument are based, are extracted from EcoWin Pro. As no price information is available for the bonds, yield data is used instead. For the German government bond the data are German government benchmark bond daily 5-year bond yields (close) and are from the period of 10.4.2002-5.12.2003. Similarly, for StoraEnso Oyj corporate bond the data are daily average 5-year bond yield for Eurozone BBB-rated corporate benchmark bonds and are from the time period of 10.4.2002-5.12.2003. Finally, the data for the Nokia Oyj equities are for the period of 10.4.2002-5.12.2003 and are the daily closing prices for the stock. In addition, to compare the data to the swap German interest rate swap daily 5-year yield (close) from the period of 10.4.2002-5.12.2003 is used to approximate the interest rate swap. In addition to the 5-year bond yield data, also 4-, 3- and 2-year bond yield data are obtained for both of the bonds to take into account the change in the volatility of the bond with time. This data are again for the same time period.

7 Qualitative risk analysis

7.1 Counterparty risk

7.1.1 Current and future potential exposure

The nominal principal of the case swap is 100 000 000€. The average net credit exposure is about 1% of the nominal principal (Hentschel and Smith, Jr., 1997), which in this case should only be about 1 000 000€. Thus the exposure amounts and related collateral requirements are quite low in connection with this case interest rate swap, implying only minor counterparty risk in terms of both absolute and relative Euro amounts. However, as stated by the theory, the potential future exposure varies greatly from its average value creating substantial possibilities of insufficient collateralisation. The variation around the average exposure should be highest at the beginning of the exposure period but then reduce as time goes on and the agreement matures, as the interest rates have tendency to mean revert over long horizons and the amortization effect dominates (see e.g. Bessis, 1998). Thus the potential for insufficient collateral is at its highest soon after the beginning of the contract and the probability decreases towards the maturity.

Both counterparties might face counterparty exposure during the life of the contract, i.e. during five years. However, the exact distribution of the exposure among the counterparties depends on the path the expected interest rate swap value takes. The value moves most likely more or less around zero, implying that the value can be both negative and positive when observing from the point of view of one counterparty. This is due to the fact that term structures are not static and they change over time. This implies that during some sub-period the first counterparty faces exposure and during some other sub-period the other counterparty faces exposure.

As the case interest rate swap is one in which the counterparty, whose exposure profile is observed, receives fixed payments and pays floating payments, the profile will most likely be an S-shape curve, which starts from zero, then increases to some peak exposure figure and after that decreases and most likely turns into negative figures for some period before returning back to zero. However, the underlying term structure profile has an important effect on the exposure profile shape. The above-described profile is a result of steeply increasing

term structures that even out after the surge in the beginning. Other term structures behaviours generate different kinds of exposure profiles for interest rate swaps.

7.1.2 Counterparty rating

As the counterparty rating varies from BB to AA (Standard and Poor's) in the case example and their probabilities of default range from 12,38% to 0,27%, the rating must evidently have some contribution to the residual counterparty risk the financial institution faces. Differing amounts of collateral need to be required from different counterparties according to their riskiness. More has to be required from the more risky counterparty to guarantee collateral coverage at any point. Counterparty rating affects the collateral amount through threshold amount, independent amount and minimum transfer amount. The magnitude of this effect depends on the approach that the other counterparty takes, implying whether it likes to be very conservative in setting these amounts or if it trusts the other counterparty regardless of its rating.

In conservative scenario, no credit risk is assumed without collateral, implying zero thresholds, there is a rather high buffer against the volatility of the derivatives position between determining and delivering the collateral amount and any amount of collateral has to be delivered thus minimising the credit exposure. Thus in this case it can be assumed that collateral requirements are quite high and each counterparty has to deliver collateral. Threshold amounts are not present restricting collateral requirements of any amount, independent amounts increase the required collateral and even the smallest amounts of collaterals has to be delivered as no minimum transfer amount is set. Thus there should not be any residual counterparty risk left and the collateral amount should be big enough to cover variations in exposure value. However, the risk of overcollateralisation is present due to high independent amounts.

In the realistic scenario some credit risk is assumed without any collateral, there is small buffer against the exposure volatility during the collateral delivery period for certain counterparties and the credit rating of the counterparty has an effect on the minimum transfer amount. Thus in this scenario collateral requirements are moderate but they exist. Threshold amounts provide some relief to the collateral delivery for the collateral giver thus adding at the same time to the counterparty risk faced by the collateral receiver. Small independent amounts decrease the collateral amount required but at the same time decrease the buffer

against adverse exposure movements. Minimum transfer amounts reduce the number of collateral deliveries. However, they add to the exposure faced by the collateral receiver. Collateral might turn out to be insufficient to cover exposure volatility and some level of overcollateralisation might occur.

Finally, in trust scenario rather high threshold amounts are set implying that the other counterparty is willing to assume credit risk an amount corresponding to the threshold amount without any collateral. No buffer against the exposure volatility is set and minimum transfer amounts are rather high, thus increasing the credit exposure. Thus in this scenario the counterparty assumes a rather high amount of counterparty risk and tries not to buffer against it with independent amounts. As a consequence collateral calls are at minimum or they do not exist, implying that exposures from the interest rate swap are lower than thresholds or the combination of the three amounts. In this scenario the probability for insufficient collateral is highest.

7.1.3 Collateral instrument riskiness

Volatility, liquidity and issuer credit quality

The first collateral instrument, Euro cash, is a risk-free instrument. It is extremely liquid and its value is not volatile. There is no specific issuer as such related to this instrument, thus there is no issuer risk involved. Thus no haircuts need to be applied. Cash as stable collateral does not contribute to the residual counterparty risk.

The second collateral instrument, the German government bond, is extremely liquid. German government bonds are liquid with one of the largest secondary markets in the world and all German government bonds are traded actively in all German stock exchanges and over-the-counter abroad (The market for German Federal securities, 2000). The price of the bond is only slightly volatile and the issuer risk related to this collateral instrument is negligible, as the issuer is a sovereign with rating AAA. Quite moderate haircut, 4%, is applied to protect against possible price changes of the government bond. If the haircut applied is correct, the collateral instrument is protected against price volatility and the collateral should not affect the residual counterparty risk.

A corporate bond has a lower liquidity than government bond although it is traded in a recognized exchange. The trading volume is quite low, making the liquidity of the bond quite

low. Its price is moderately volatile as a consequence of infrequent trading. The price information is quoted daily but there are usually only minor changes and few trades announced (www.storaenso.com). There is also some level of issuer risk present as the issuer, i.e. StoraEnso Oyj, is rated only at BBB+. A slightly higher haircut, 6%, is applied to take into account the price variations of the corporate bond. If the haircut is not proper or adjusted correctly, price fluctuations of the bond could cause some residual counterparty risk. Also low liquidity and issuer default possibility contributes to possible residual counterparty risk.

Although traded in a recognised exchange and included in main index, Nokia Oyj equities are the most volatile and thus most risky collateral instruments in the study. The share price has declined about 20% in one-year period and about 67% in 3 years (www.hexgroup.com). Equities are, however, usually extremely liquid if they are traded on an exchange. Nokia Oyj equities have been traded actively during the past five years implying a relatively good liquidity (www.hexgroup.com). This form of collateral instrument might also present some issuer risk, as the issuer credit quality might be low. In this case, the issuer rating is A, which is relatively high. The haircut applied to equities is the highest among the sample collateral instruments, namely 15%, as the price volatility of equities is quite significant. Here again insufficient haircut to protect against price volatility or issuer default adds to the counterparty risk.

Correlation with underlying position and counterparty's creditworthiness

Cash has no correlations either with the collateralised counterparty or the underlying exposure.

German government bond should not have any negative correlation with the underlying exposure (euro swap) or positive correlation with the counterparty (British financial institution). In fact, as the interest rates rise, the value of the case swap decreases, as does the value of the collateral bond. This possible positive correlation might even be desired as it protects against possible residual counterparty risk.

StoraEnso Oyj corporate bond possibly has some correlations either with the exposure or the collateralised counterparty. There exists similar positive relationship between the exposure and the corporate bond as with the government bond. However, in the worst case, the bond might have a positive correlation with the swap counterparty, which happens if the issuer

operates in very similar business as the counterparty (in this case forest industry company vs. financial institution) or the corporate bond issuer is somehow dependent on the counterparty. In this case, indeed, many of the managers of the StoraEnso Oyj corporate bond program are British financial institutions (www.storaenso.com). Thus there might exist some unwanted positive correlations between the collateral and the counterparty. Unwanted correlations add to effective exposure.

Equities might have some unwanted correlations that make the collateral less preferable. In this case, there should not be any positive correlations between the counterparty and the collateral, as the collateral issuer operates in very different business, namely telecommunications. Neither should there be any clear correlations, either positive or negative, with the underlying exposure, as equities do not react to interest rate changes in a straightforward way.

7.1.4 Residual counterparty risk related to collaterals

As a summary it could be assumed that in this case residual counterparty risk related to collaterals exists. Exposure profile of the interest rate swap is rather volatile, counterparty ratings have an effect on collateral requirements through different amounts, thus affecting the possibility of insufficiency of the collateral if inaccurate amounts are set, and some of the collaterals are volatile and might have some unwanted correlations with the exposure leading again to insufficiency, regardless of the haircut applied. Also the risk of overcollateralisation and counterparty default for the collateral giver is present as ratings based amounts can be set inappropriately too high.

7.2 Legal risk

The legal risk analysis will focus on three different jurisdictions, as stated in the case description. These are the law of the residence country of the financial institution (Finnish law), the law of the counterparty's residence country (English law) and the law of the country of the custody (Belgian law). The English law CSA is applied to the collateral agreement.

In general, the EU Directive on Financial Collateral Arrangements, which will be implemented in national legislations by December 2003, will help to overcome major legal problems, such as differences in perfection and enforcement requirements. In general, it will reduce the systemic risk related to collaterals. Also the Hague convention will provide some

alleviations to cross border legal issues. However, the EU Directive on Financial Collateral Arrangements contains some loopholes that the member countries may take advantage of, leading to differing collateral legislations (Rahoitusvakuustyöryhmän mietintö, 2003). These loopholes concern especially the scope of the directive, e.g. the inclusion of certain collateralised counterparties is optional and some securities may be excluded if wanted. Thus, the directive will not solve the legal problems entirely.

Before the EU directive is implemented and is in use in EU member countries, the biggest problem related to the cross border legal issues is probably the ever-changing law regimes in different countries and how to keep track on the changes. Yet, the target is to get an enforceable agreement every time and thus it is of high importance to know the legislations in different countries. This problem will be significantly reduced after EU directive implementation and Hague convention ratification. However, there will still be countries that are outside of these regulations but who are nevertheless possible counterparties for collateralised transactions. The directive will only apply to EU member countries and the Hague convention in the countries that will ratify it.

7.2.1 Perfection requirements and enforcement of collateral agreements (lex contractus) and collateral arrangements

The perfection requirements and enforcement of collateral agreements and collateral instruments have not been seen as a major problem to date. The law governing the collateral agreement is explicitly stated and the validity of the agreement is thus clear and undisputed. In all of the three countries the lex contractus applies, implying that the law governing the contract and its validity between the counterparties is the law applied to the contract. Thus it will be either English, New York or Japan law. In this case, it is the English law.

The perfection requirements of collateral arrangements, on the other hand, vary between England, Finland and Belgium. In England, to create a valid collateral arrangement, it may be required that the security interest, i.e. a pledge, has to be registered with certain state agencies. This implies that the instrument creating the charge, together with prescribed particulars, must be delivered to the Registrar of Companies within 21 days from the creation of the charge (ISDA, 2000c). This applies, however, only to the companies registered in England or companies registered outside England that has an established place of business in England. This requirement depends on the terms and nature of the charge and is thus not applied to

every security interest. These rules do not apply to titles of transfer. In Finland and in Belgium, on the other hand, no official registration of a security interest is necessary.

However, both in Finland and in Belgium, certain other formal requirements must be fulfilled in order to perfect the security interest. In Finland, an agreement must exist between the collateral giver and receiver. Cash or receivables as pledged collateral must be notified to the person from whom the receivable is due, e.g. bank (Promissory Notes Act). Certified securities are perfected when the physical possession of the securities is transferred. Perfection of book-entry items is achieved by registering the pledge as an entry in the relevant book-entry account (Act on Book-Entry Systems). In Belgium, similarly, pledge is perfected by entering into a pledge agreement and by disposing the pledged asset. If held by a third party, the security interest should be notified to the third party. Cash should be delivered to the collateral receiver or a third party and fungible securities should be booked to a special account. In these two countries the perfection requirements are very similar. Similar procedures are required in Finland in the case of title transfer, although the ownership to the collateral is received solely based on the agreement. In Belgium, same rules do not apply to transfer of title. (ISDA, 2000a; ISDA, 2000b)

Also the enforcement procedures vary between these countries. In England, no formal procedures are needed to enforce the collateral in the event of a default by the counterparty. In England the enforcement is usually carried out by selling the collateral. No court approvals or auction procedures are required and the English law does not prevent the collateral receiver from exercising its rights given in the collateral agreement. In Finland, no court judgement is required. In addition, no particular methods of enforcement are required (Commercial Code). However, to be able to liquidate the collateral the secured liability must be due, the owner of the pledged assets must be notified of the sale, which will happen after certain time period and the time period must have been elapsed without settlement (Commercial Code). These rules are not mandatory and may be changed by agreement. The enforcement procedures are the most stringent in Belgium. In the case of collateral whose price is not readily available, cash may be collected but fungible securities are enforceable only after court authorisation. Collaterals with readily available price can be enforced after notifying the collateral giver and the collateral must be sold in a private or public sale in regulated markets. The proceeds must be applied to the underlying obligation. (ISDA, 2000a; ISDA, 2000b; ISDA, 2000c)

According to the *lex rei sitae* the laws of the countries described above are only applicable and relevant when the collateral instruments are located in the respective countries. Thus, in relation to the example case, the Belgium law would be the law that would apply to the perfection and enforcement of the collateral instrument as the instruments are assumed to be held in Euroclear Bank, which is located in Belgium. Thus the perfection requirements do not seem to be very complicated but the enforcement procedures are more cumbersome. However, to provide further certainty for the collateral pledged in Euroclear, there are some simplified requirements for the collateral instruments held in Euroclear in Belgium (Thieffry and Bridson, 2000). Thus the requirements presented by the general law of the Belgium need not be followed.

EU Directive on Financial Collateral Arrangements

The collateralised counterparties described in the case would all be subject to the EU Collateral Directive. The directive applies, among other things, to financial institutions, to interest rate swap transactions and to cash and securities collaterals, thus it would apply also to the case counterparties, instruments and transaction of the study. Hence, as the EU directive precludes any perfection and enforcement requirements related to collateral instruments, no risk related to perfection and enforcement should remain. The directive, however, presumes that the collateral must be provided and the provision evidenced in writing in order for it to be valid (02/47/EC). The directive nevertheless restricts any additional formalities required to perfect collateral arrangements and precludes any formal or procedural requirements on the enforcement. Before the directive is implemented in the countries the counterparties will have to comply with the laws determined by the *lex rei sitae*, in this case the Belgian law.

To sum up, there should be no major problems as to what constitute the perfection requirements in Belgium and thus no risk of unenforceable collateral agreement should occur. After the implementation of the EU Directive, the risk is further reduced.

7.2.2 The 'lex rei sitae' rule and location of securities

The perfection and enforcement procedures described in the previous section are applicable only if the collateral securities are located in the respective countries. This implies that when the collateral instruments are located in Finland, the Finnish law applies, when they are situated in Belgium, Belgian law applies etc. However, the location of the securities might be

somewhere else or it may change during the contract period. In all of the three countries, so-called *lex rei sitae* -rule applies. It means that the law applied to the collateral arrangement is the law where the collaterals are situated. However, different legislations may differ in their view of what constitutes the *lex rei sitae*.

In Finland the *lex rei sitae* rule is given in the Netting Law (12§); the law applicable is the law in that country, where the right is recorded in register or account, if the security is not publicly issued in writing or if it is given to be held in a deposit system. In the case of cash collateral the country would be the country of the debtor, with regard to certified securities the place where the certificate is located, dematerialised securities (book-entry securities) would be deemed to be located in the place where the register recording the interest is located and with regard to immobilised securities the place would be where the certificates are physically located. (ISDA, 2000b)

In England the rules are similar. The law governing the deposit would be applied to cash collateral and the law of the jurisdiction where the securities would be regarded as situated (i.e. certificate's location or register's location) would be applied to fungible securities. The Belgian law determines the locations of collateral securities in a very similar way, too. In relation to cash, the law applicable is the law of the place where the bank holding the account is located. Registered or dematerialised securities are deemed located where the register or booking systems are located. And bearer securities are located where they are physically held. Thus in all of the three countries the location of the collateral instruments are quite explicitly expressed and there should not be any problems related to the determination of the location and thus the law to apply. Also the location of the book-entry securities, which are common in modern markets, is clearly stated. (See e.g. ISDA, 2000a; ISDA, 2000c)

Belgian law provides again a simplification to the determination of the location of the securities when held in Euroclear Bank. All interest in securities held by Euroclear are deemed located in Belgium and thus Belgian law applies to the perfection and enforcement (Thiefrry and Bridson, 2000). This is regardless of where the certificates representing the securities are located. Clearstream Banking provides similar simplifications (Thiefrry and Bridson, 2000). And as stated, both also provide the possibility to perfect the collateral without the formalities stated in the general law. Thus only the legislation of the place of the intermediary need to be looked to. Thus, if collateral securities are held in Euroclear or

Clearstream Banking, there should be no problem in defining the location of the securities and thus the applicable law to perfection and enforcement.

EU Directive on Financial Collateral Arrangements

The EU directive includes an article (article 9) that provides a general rule for determining the law that applies to collateral instruments. However, article 9 applies only to book-entry securities and book-entry accounts. It states that the law applicable is the law of the place where the relevant account is maintained. Thus the article is consistent with the English, Belgian and Finnish laws and would thus not change the way the location of the collateral is determined in these countries. (02/47/EC)

Hague convention

The main effect of the Hague convention is to offer another way to determine the applicable law and the location of the securities. The Hague convention applies the so-called PRIMA rule. The PRIMA approach implies that the law applicable to the proprietary rights related to the securities held with intermediaries is the law of the country determined in the agreement between the account holder and the relevant intermediary, provided that the relevant intermediary has operations in this country (Hague convention #36, 2002). Thus, if ratified, the Hague convention will change the *lex rei sitae* to the law that was decided in the custody agreement. This would change the law applicable to the collateral securities significantly. However, the convention has not been ratified yet.

7.2.3 Bankruptcy legislation (lex concursus)

The law of the residence country of the insolvent counterparty applies to the insolvency proceedings. Thus, the *lex rei sitae* or the law applied to the agreement do not apply in this case. Thus, again, the three different legislations need to be examined.

Stay or freeze

In Finland, the enforcement of a security interest may sometimes be delayed and is stayed on insolvency. Under the Finnish Restructuring Act, the restructuring proceedings will result in a period of protection. During this period it is not possible to liquidate collateral. Similarly, if the operations of a credit institution have been suspended, under the Commercial Bank Act, Savings Bank Act or Cooperative Bank Act, it is likely that collateral cannot be enforced during the suspension period. This would even override the English law CSA and stop

liquidation even in another country (ISDA, 2000b). However, in Finland, the Netting Act allows the netting of certain obligations irrespective of the restructuring or bankruptcy proceedings. The precondition is that the obligation was entered into before the commencement of the proceedings. It does not however allow the realisation of collateral pledged to credit institution.

In England, on the other hand, the enforcement procedures of pledged collaterals cannot be subject to any delay or stay in insolvency. Although an administration order may be made by the court in the case of possible insolvency of the counterparty, and this administration order would stop the possibility to enforce any security over the company's property, it would not, however, prevent the other counterparty from exercising an early termination, close-out netting or contractual set-off rights (Insolvency Act). Thus, no stay period would exist and collateral could be liquidated. (ISDA, 2000c)

Under the Belgian law, the legislation governing the stay and freeze is a bit more complicated. Any security interest may be subject to stay or delay, but it does not apply to title transfers. Belgian insolvency law might delay the collateral liquidation. Under both bankruptcy proceeding and judicial composition proceedings (Bankruptcy Law and Law on Judicial Composition), the enforcement of collateral right may be delayed up to six months or one year, depending on the bankruptcy law applicable. There exist some exceptions, however, and for example government securities pledged as collateral are not subject to suspension of rights. (ISDA, 2000c)

To sum up, in Finland and in Belgium there are certain restrictions on the collateral liquidation. Thus the collateral receivers standing is worsened in these two countries and the receiver could not cover possible losses due to counterparty insolvency.

Top-up collateral

The Finnish Recovery Act provides that any security given within three months before the insolvency proceedings is liable to recovery. This means that the collateral provided within this time period will be deemed null. However, this is true only for some cases and in other cases the top-up collateral will not be deemed invalid. Again, the Netting Act allows some deliveries of collateral not to be subject to avoidance. The transactions are limited and there

should be a liability for the collateral giver to deliver additional collateral for the Netting Act to apply. (ISDA, 2000b)

In England, if the motivation of the collateral giver when delivering top-up collateral during the six-month period before insolvency proceedings has been purely to fulfil its contractual obligation and not to favour the receiver in any form, the delivered top-up collateral would not be vulnerable as preference according to the Insolvency Act. Thus, in England, top-up collateral can only be deemed as null, if it is made in favour of the collateral receiver. (Insolvency Act)

According to the Belgian law, the top-up collateral will not be avoided as a preference. There exist, again, some conditions under which this is true. Only repo and title transfer deliveries are considered valid if delivered during the preference period. Top-up collateral deliveries in the form of pledge are usually deemed invalid, unless they are delivered with sufficient consideration and not for example for old debts.

To summarize, there is some risk in England and in Belgium related to the top-up collateral, and even higher risk in Finland. If the top-up collateral is declared invalid, the collateral provider, i.e. the insolvent counterparty may recover the collateral from the solvent counterparty and leave it without any cover against its default.

EU Directive on Financial Collateral Arrangements

It seems that there are quite big differences between English, Finnish and Belgian law in the bankruptcy legislation and thus the risk related to the event of default by either of the counterparty would be quite significant. Stay and delay periods exist, hindering an efficient liquidation of collateral and top-up collaterals may be deemed invalid. However, the EU Collateral Directive, again, states that for example top-up collaterals may not be declared invalid during certain preference period just because they were delivered during this period. However, no certain rules exist in the directive that would forbid such preference or stay periods. Thus, counterparties to collateralised transactions face this risk in the event of counterparty default.

7.3 Other risks

7.3.1 Liquidity risk

Liquidity risk related to collateral usage, in the form of the need to be able to fulfil collateral calls in a timely manner, can be deemed to be only minor. First, the collateral calls in this case are quite small and it should not be a problem to fulfil these calls. Second, the risk is minor because more and more financial institutions that operate with collaterals make use of central counterparties (CGFS, 2001). The liquidity risk is effectively reduced by the use of central counterparty, such as Euroclear Bank, because they offer collateral management services that facilitate to meet the collateral calls efficiently. Even with higher and more substantial collateral calls, this form of liquidity risk is reduced to minimum. Also new collateral practitioners benefit from central counterparties as they usually are already members of some central counterparties before initiating collateralisation.

Euroclear Bank has a special Integrated Triparty Derivatives Support -system, which is designed to facilitate the collateralisation of net exposures from OTC derivatives transactions. To be able to make use of this service, the counterparties have to be members of Euroclear. The Euroclear's Brussels office (Morgan Guaranty Trust Company, MGTC) acts as a collateral agent. The collateral service is based on the securities pool that clients have in Euroclear. This pool is usually held in Euroclear for example for clearing and settlement purposes and to guarantee trading volumes. However, the same pool is used as a source of collaterals. The liquidity risk reduction by this service is based on the fact that the securities pool that the counterparty holds in Euroclear is the source of collateral instruments and this pool is quite large, as Euroclear requires quite high limits to be able to clear through it. Thus the collateral calls are quite easily met by using the instruments in the pool. The pool covers the instruments that the counterparty uses normally in settlement, for example cash and bonds. The Euroclear's automatic securities selection system, AutoSelect, further facilitates to reduce liquidity pressures. This is because AutoSelect optimally selects and allocates the most suitable securities, i.e. those with match with the pre-defined eligibility criteria, for collateralisation. Thus calls are met in time and with right instruments. (See www.euroclear.com)

It should be noted, however, that the same pool that is used for collateralisation is also used for trading and settlement. In the event of unusually active trading, the pool might be required

as a guarantee for settlement and no instruments can be used as collateral. This is however very unlikely as the pools are rather high in value.

Clearstream Banking provides also a very similar service. Although not especially designed for derivatives transactions, but generally to all transaction requiring collateralization, Clearstream's Collateral Management Service offers similar alleviations to the liquidity risk as does Euroclear. Users of the service are not required to maintain a special account with the bank. The service supports a discount window borrowing from major central banks and a choice of fully collateralized securities lending programs, thus making it easier to fulfill collateral calls in a timely manner. They also provide automatic collateral selection that selects the most suitable collateral instruments for each situation thus further facilitating the liquidity risk. (See www.clearstreambanking.com)

Additional source of liquidity pressures related to collateral usage is the use of thresholds when calculating collateral requirements. If the credit rating of the collateral provider suddenly changes collateral calls increase, as threshold decreases. This source is however nowadays only of minor concern, since the trend is towards zero thresholds. However, liquidity pressures might be worsened through the use of independent amounts, since they are usually applied and they change similarly according to credit rating changes. This source of liquidity pressure is only minor, as the participants providing collaterals usually have quite high ratings with only a little possibility that there is a sudden change in the rating. Of more concern might be the credit rating of the collateral receiver.

The widespread use of cash as collateral (85% of collateral practitioners deliver US cash and 70% deliver Euro cash, ISDA 2003) also implies that the liquidity pressures are not significant in reality. If cash is used, it is in practice always available, e.g. by using repurchase trades, and thus suitable collateral instrument is always at hand. Cash would especially be a way to reduce liquidity pressures for collateralised counterparties not using central counterparty services.

7.3.2 Operational risk

As the collateralisation of OTC derivatives transactions is quite a new phenomenon, many market participants do not have standard, sophisticated, well-functioning collateral valuation systems and softwares. More likely, they have systems built in-house that they operate

manually with only little experience. This is probably the biggest operational risk related to collateral usage. The underlying assumptions, collateral determination functions and collateral call or delivery triggers in the model may be inadequate or incorrect, causing model risk. The data for the model is inputted manually, causing possibility for significant errors. However, this operational risk has to be taken since it is not necessarily possible for a new collateral practitioner to immediately acquire a standard model. A suitable model might not even exist for a beginner. Another source for operational risk is inadequately skilled personnel. This risk is also related to the fact that collateralisation is a new phenomenon. Also the systems and operations of the custodian add to the operational risks.

The operational risk related to collateral systems and models is fortunately reduced by the fact that in the beginning there are usually only a few collateralised counterparties, volumes are low and only the safest possible collateral instruments are used. In-house built models also provide an excellent way to learn about collateralisation. When collateral activity expands, more sophisticated systems are needed to avoid operational risks.

There are a number of collateral system software vendors in the market. The most visible ones are probably Algorithmics Inc. and SunGard Inc. They both offer collateral management systems, Algo Collateral and SunGard Collateral respectively, that can be implemented into the institutions own systems and operations. These are standardised user-friendly softwares that facilitate to overcome the deficiencies related to manual models based on for example Microsoft's Excel.

7.3.3 Custody risk

Even though participants in the market using collaterals increasingly make use of third party services, such as Euroclear's collateral management service, and these services facilitate to reduce some risks related to collateral usage, they might entail themselves other risks.

First of all, the custody might default. If, however, reliable and well-established custodies such as Euroclear or Clearstream Banking are used there is only a limited possibility that the custody will default. They are usually highly rated entities with high standards and firm capital bases. They are important players in the collateralisation process and do not afford to default. Euroclear, for example, has a rating of AA+ and Clearstream Banking AA+. Thus it can be noted that the default risk associated with the custody is of minor concern. These

entities have usually also very stringent rules and procedures in place to protect collateral practitioners' assets if default were to occur.

Custody risk might arise also from the way the custody handles the securities held in it as collateral. In Euroclear collaterals are taken from the counterparty's own securities account and they are delivered to a special segregated collateral account of the other counterparty. Thus the securities are kept apart from Euroclear's own assets. Hence, this form of custody risk is also reduced. (www.euroclear.com)

Also the operations and systems of the custody might cause some risk. If the systems inside the custodian fail, there should be some back-up systems to guarantee that nothing happens to the securities of the participants and that the collateralisation process continues to perform uninterrupted. Also the personnel involved in the collateralisation process should be qualified enough. This is the area of the operational risk which can be the most difficult to assess, as information regarding systems and back-up plans is not necessarily available.

7.3.4 Concentration risk

Concentration risk should not be a major concern for collateral practitioners who either accept only cash and government bonds as collateral or who, in contrast, accept a wide range of collateral instruments. If cash and government bonds are accepted and there exists some concentration on certain government bonds, there is only a minor chance that the risk of this concentration would materialize. This is because sovereigns are highly rated with practically no possibility of defaulting. On the other hand, cash does not have a particular issuer and this form of risk does not exist. However, if certain less stable currencies are accepted, instead of mostly used US dollars or Euros, and the cash collateral consists mainly of one currency, there exists a risk of currency devaluation. Such currencies are not accepted by Basel II as eligible collateral and also ISDA recommends the use of Euro and US dollar cash.

If, on the other hand, a wide range of collateral instruments are accepted there is a little chance that the collateral base would consist of only one type of collateral. As Basel II now allows a wide range of instruments to be accepted, this reduces the possibility of facing concentration risk. In addition, most collateral management service providers apply concentration limits (e.g. 10%, 25%, 50% etc.) to the riskier collateral instruments thus limiting the exposure on one type of collateral.

7.3.5 Systemic risk

The systemic risk generated by collateral usage is mainly due to legal risk and liquidity risk related to collaterals. Even though collateral usage might reduce the systematic risk by reducing counterparty risk in general, legal risk and liquidity risk related to collateralisation might increase the systemic risk. However, as noted earlier, the legal risk related to collaterals is greatly diminished by the implementation of the EU Directive on Financial Collateral Arrangements into the national legislations and by the adoption of the Hague convention and PRIMA rule. Actually, one of the main tasks for the EU directive is to diminish systemic risk. Also the liquidity risk is only minor related to collateral usage due to the increased use of third party collateral management services. Thus the systemic risk is only moderate.

7.4 Summary of the qualitative risk analysis

Based on the analysis in this chapter it can be said that most of the collateral risks are somehow managed. Some of the risks are more severe than the others and their importance for the collateral practitioners is higher than of the others. The range of the risk categories composes of the basic financial risks that are related to many other transactions and procedures in the financial markets.

Table 7 gathers all of the risks related to collaterals in one table with their relevant importance, primary source or contributors and possible solutions.

Risk	*Importance*	*Primary source/contributors*	*Management*
Counterparty risk	HIGH	Insufficient collateral; high collateral and exposure volatility, long exposure period	Haircuts, threshold, independent and minimum transfer amounts, proper valuation systems, frequent valuation
Changing risk profile of the collateral pool	HIGH	New collateral instruments with lower quality, scarcity	Haircuts, Basel II, ensuring a source for high quality collaterals, economising on existing collateral pool
Legal risk	MEDIUM	Contract enforceability, not sufficient rights to collateral in every jurisdiction	EU directive, Hague convention
Liquidity risk	LOW	Frequent collateral calls, low collateral liquidity	Custody securities pool, cash, abandoning of thresholds
Operational risk	HIGH	Collateral valuation models, collateral management systems, humans	Standard models, checks, back up systems; education, learning
Custody risk	LOW	Custody default/fraudulence, custody systems	Reliable custodies used, e.g. Euroclear, Clearstream Banking; segregation
Concentration risk	LOW	Collateral pool	Wide range of collateral instruments accepted, cash, concentration limits
Systemic risk	LOW	Legal risk in the form of contract enforceability; liquidity risk in the form of collateral calls	EU directive, Hague convention, Basel II; custody security pool, cash

Table 7 Collateral risks, their relevant importance, primary source or contributors and a management method

8 Quantitative risk analysis

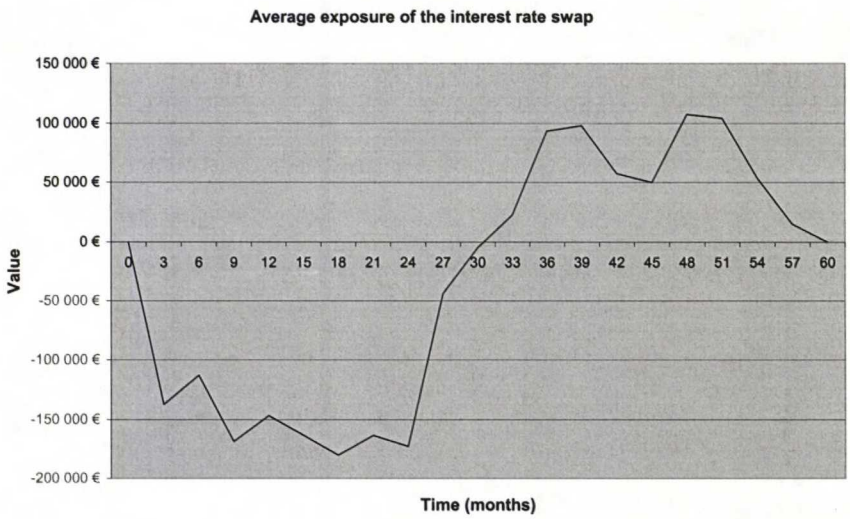
In this quantitative part of the study, the current and future potential exposures are first described and evaluated, thus showing how the interest rate swap counterparty exposure behaves. Next, the effects of counterparty rating (i.e. the applied amounts) and collateral instrument riskiness (i.e. the haircut) on collateral determination are shown with examples. After that the residual counterparty risk related to collaterals is examined. The two most important factors affecting this risk, namely the volatility of the underlying exposure and the volatility of collateral instrument are both examined. In addition, correlations between collateral instruments and the underlying exposure are evaluated. The examples and analyses in this chapter are based on the case described in Chapter 6 and the calculations are based on the simulation, valuation and determination models and methods described also in Chapter 6. The exposure volatility is examined based on the simulated swap values and Car-analysis. The collateral riskiness evaluation, on the other hand, is based on historical time series data.

8.1 Evaluation of current and future potential exposure

8.1.1 Current exposure

The expected counterparty exposure profile of the interest rate swap after 1 000 simulations is presented in Graph 5. The graph depicts the exposure seen as of time point zero, i.e. the exposure that would be realized if the interest rate term structures would be realised as predicted at time zero. In this study, the interest rate swap is assessed seen as of initiation and the whole five-year maturity is evaluated. No assumptions or evaluations are made observing the swap as of some future date during the maturity. The collateral requirements are thus based on the expected exposure seen as of time zero.

Graph 5 The expected exposure of the 5-year interest rate swap (1000 simulations)



At initiation the value of the interest rate swap contract is zero, as it should be by definition. Also at maturity, the value decreases to zero, as no principal is exchanged. In the beginning, during about the first three years of the contract, the financial institution, from whose point of view the swap is evaluated, is out-of-the-money in the contract. It has to post collateral, as there exists counterparty risk, i.e. possible loss, for the in-the-money counterparty. There is no counterparty exposure for the institution at that time due to the interest rate swap. However, during this period the institution faces counterparty risk due to the posted collateral in the form of possible overcollateralisation and counterparty default risk. The other counterparty, on the other hand, faces the risk of insufficient collateralisation and possible residual counterparty risk.

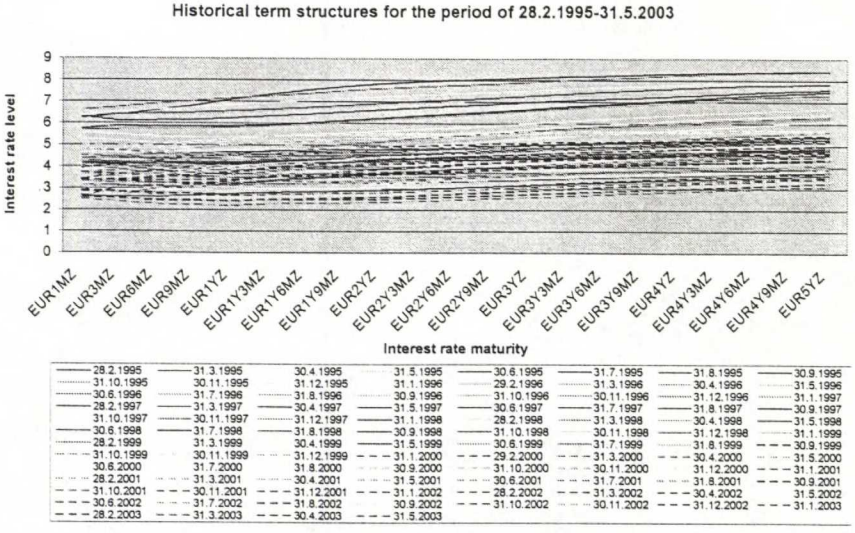
Between months 30 and 33 the interest rate swap value turns to be positive for the institution and thus it is in-the-money. Hence, the institution requires collateral from the counterparty to cover the exposure and possible losses during about the last two years of the contract. During this period, the situation is reversed and the counterparty risk for the financial institution arises both due to the interest rate swap and the collateral instrument. The collateral may turn out to be insufficient because of high volatility, low liquidity, low issuer credit quality or undesired correlations. Also the underlying exposure may change rapidly. The other counterparty posting the collateral now faces the risk of overcollateralisation and the counterparty default risk.

The lowest expected value of the interest rate swap is reached during month 18 when the value amounts to −180 301€. This would be the month when the default by the financial institution would be the most financially damaging for the counterparty and also when the institution needs to post the largest amount of collateral. On the other hand, the highest value of the contract, 107 371€, is achieved during month 48. This would be the most financially damaging time for the institution, if the counterparty were to default. It would also require the highest amount of collateral at that time. For more information about the expected exposure and the distribution of the interest rate swap value at each month, see Appendix C.

It should be noted that, first of all, the exposure profile generated by the simulation is rather erratic. This is due to the fact that term structures of interest rates are not static throughout the life span of the swap. Instead, they change as time evolves. Secondly, the reversed S-shape of the exposure profile is a consequence of quite flat term structures that bend slightly in the beginning of the simulation period and then increase moderately. Graphs 6a and 6b plot the historical term structures on which the simulation is based and a sample set of simulated term structures, respectively. Third, the average exposure amounts are quite low compared to the nominal principal of the swap (100 000 000€), namely less than 0,1% of the nominal principal (see Graph 5 and Appendix C), which is typical for interest rate swaps. Thus also the collateral requirements will be rather low in proportion to the nominal principal of the swap.

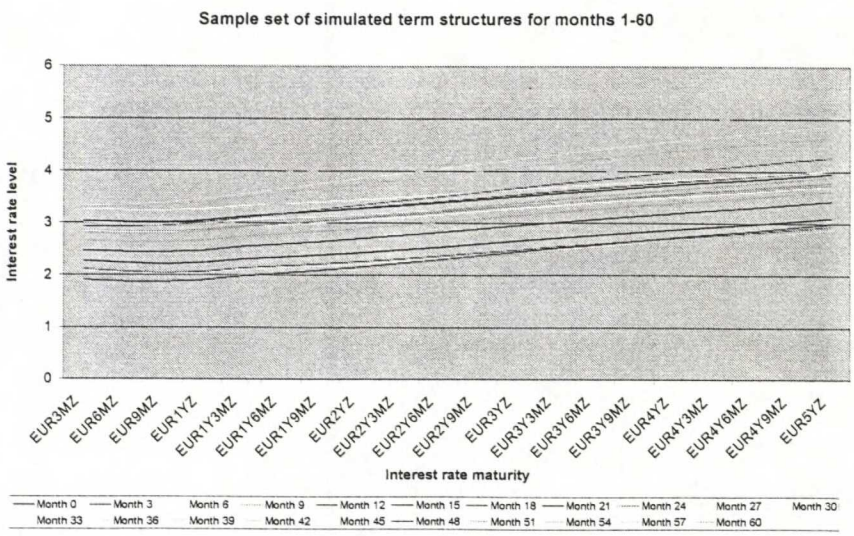
Graph 6a Historical monthly term structures for the period of 28.2.1995-31.5.2003

The graph depicts the observed term structures at each month during the period of 28.2.1995-31.5.2003. The interest rates range from one month (EUR1MZ) to five year (EUR5YZ) interest rates and are expressed for every three months.



Graph 6b Sample set of simulated monthly term structures for months 1-60

The graph depicts a sample set of simulated term structures at every three months between months 0 and 60. The interest rates range from three month (EUR3MZ) to five year (EUR5YZ) interest rates and are expressed with three-month intervals.



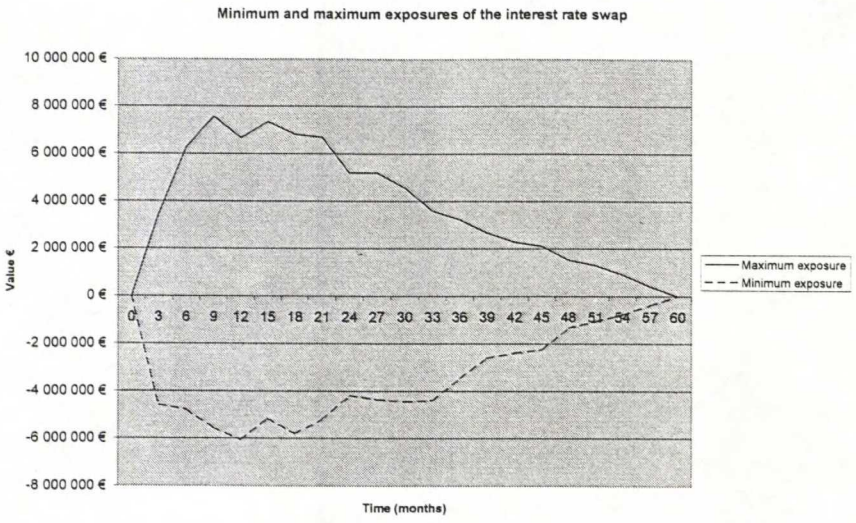
8.1.2 Future potential exposure

The simulated values for the interest rate swap deviate significantly from the expected value especially in the beginning of the agreement period. As the agreement matures, the standard deviations get smaller and smaller. This is also true in practice, since there are less and less payments coming as the agreement matures, thus the amortization effect dominates the

diffusion effect (see e.g. Bessis, 1998), and the interest rates tend to revert to mean. Thus the riskiness of the interest rate swap decreases as it matures and its value gets more stable.

The volatility of the swap value creates potential credit risk exposure in addition to the current exposure, i.e. the mark-to-market swap value, as depicted by Graph 5. This variation peaks at time point 15, after which it decreases towards zero. This variation of the value around the average exposure value can be seen from the Graph 7 that exhibits the maximum and minimum possible exposure values at each time point.

Graph 7 Minimum and maximum possible exposure values of the 5-year interest rate swap



The counterparty risk related to collaterals and especially the effect of the exposure and collateral value volatility are evaluated thoroughly after first evaluating the contribution of the counterparty rating and collateral instrument riskiness to the collateral amount determination and thus its sufficiency. The next two sections are illustrative by nature.

8.2 Evaluation of the effect of counterparty rating on collateral requirement

Threshold, independent and minimum transfer amounts are set to take into account the creditworthiness of the counterparty when determining the collateral requirement or delivery amount. This is clear, since the collateral is used to protect against counterparty risk. If these amounts are set properly, especially the independent amount, it buffers against adverse movements in the counterparty exposure, and the collateral amount protects against losses in default. If not, the amounts might even add to the risk the exposed counterparty faces. Thus the independent amount, especially, is actually set to take into account the volatility of the underlying exposure. Hence assessing the role that these amounts have in collateral

determination implies actually assessing their appropriateness and their sufficiency to cover adverse movements in the exposure value. The collateral requirement examples presented in this section are based on the case information and collateral determination model given in Chapter 6. The collateral requirements are expressed as total collateral needed and not as top-up collateral deliveries. This is because the total amount of collateral matters when its sufficiency is evaluated. Top-up collateral deliveries as such affect the liquidity risk related to collaterals. See Appendix D for example calculations of collateral requirements for different counterparties with one collateral instrument.

8.2.1 Collateral giver's point of view

The financial institution is obliged to deliver collateral during the first about 30 months of the swap contract, as it is out-of-the money during that time. More collateral has to be delivered to the counterparty that has higher rating. The amounts applied to the deliverer, who is the financial institution in this case, remain the same independent of the counterparty. Only the amounts applied to the counterparties change with rating and thus the collateral requirements change.

In conservative scenario, for example in month 18 where the exposure for the counterparty is at its highest (180 301€), the collateral required by the AA counterparty ranges from 2 180 301€ to 3 648 991€ depending on the instrument used. The requirements by A rated counterparty range between 180 301€ and 301 754€ (equalling approximately the expected exposure amount). The financial institution would be obliged to deliver all of these amounts since no threshold or minimum transfer amount is applied. Under this scenario, BBB or BB rated counterparties would not require any collateral, as their independent amounts are significantly higher than the amount applied to the collateral giver.

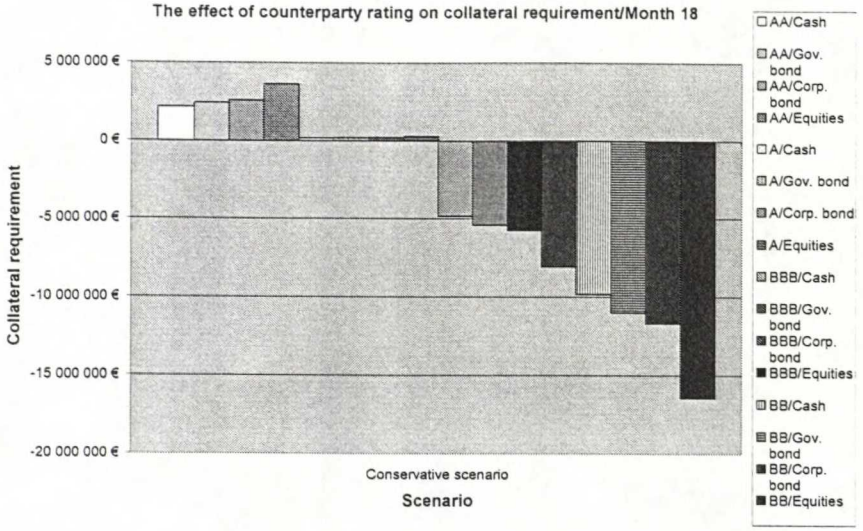
In any other scenarios, with the given threshold, independent and minimum transfer amounts, no collateral would be required from the A rated financial institution. The requirements show in fact as negative figures (as does the requirements by BBB and BB in the conservative scenario). This is because the exposure is small compared to the applied threshold amounts.

It can be stated that the independent amounts applied to the counterparties determine in general the level of the collateral requirement. On the other hand, the threshold amount and minimum transfer amount express the amount of uncovered exposure the counterparty is

willing to assume without any risk mitigation and thus they increase the exposure. Graph 8 presents month 18 as an example of how the rating and thus the applied amounts affect collateral requirement when the financial institution is the collateral provider. The graph shows also the negative requirements, which in practice would imply zero requirements.

Graph 8 The effect of the counterparty rating on collateral requirement,

The collateral requirements are grouped according to counterparty rating categories (AA, A, BBB and BB), month 18 under the conservative scenario is used as an example and the graph shows also 'negative' collateral requirements



This similar pattern can be seen throughout the period, i.e. months 3-30, when the financial institution is the counterparty delivering collateral. In other words, only AA and A rated counterparties would require any collateral under the conservative scenario and no collateral would be required under the other scenarios. This is due to AA's and A's lower independent amounts in conservative scenario and high thresholds amounts that are applied to the financial institution in other scenarios. This observed pattern actually confirms the function of the amounts; independent amount increases the collateral requirement thus protecting against exposure volatility, while the other two amounts actually lower the collateral delivery amount, thus increasing the exposure faced by the collateral receiver.

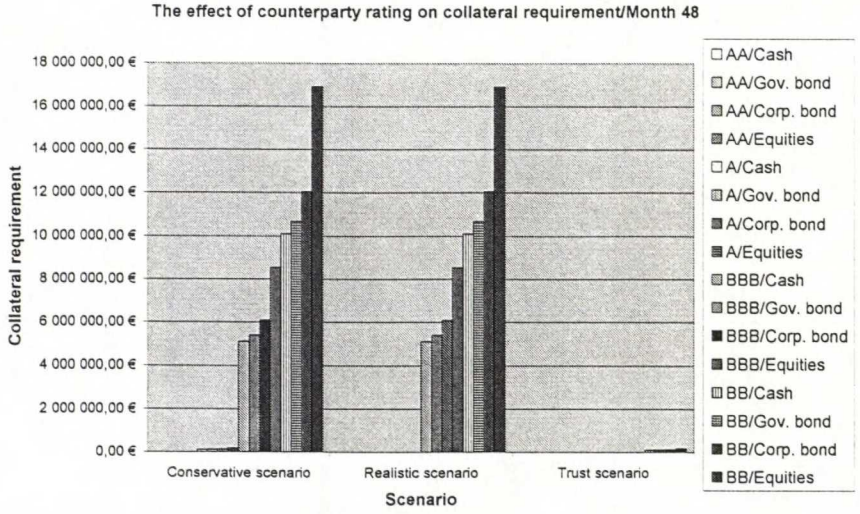
8.2.2 Collateral receiver's point of view

After about 30 months the value of the interest rate swaps turns into positive for the financial institution and it is entitled to require collateral from its counterparty. Here again, the rating of the counterparty has an effect on the required amount. Now the effect of the counterparty's rating is in a way reversed. The lower the rating, the more is required.

The time point examined is again the month when the exposure is at its highest for the collateral receiver. It is now month 48 and the average exposure is 107 370€. Graph 9 depicts month 48 as an example of how the counterparty rating affects the collateral requirement when the financial institution is the collateral receiver.

Graph 9 The effect of the counterparty rating on collateral requirement

Collateral requirements are grouped according to counterparty rating categories and month 48 under all of the scenarios is used as an example



In this case, no collateral is required from the counterparty rated AA in any of the scenarios because of the lower independent amount applied to it compared to the collateral receiver in conservative scenario and high threshold amounts in other scenarios. Only a minor amount is required from the counterparty that is rated A (107 371€-179 698€ equalling approximately the expected exposure amount) and it happens only under the conservative scenario. Higher amounts of collateral are required from the BBB and BB rated counterparties in conservative and realistic scenarios due to high independent amounts. Independent amounts are usually set to be high to cover the exposure especially with counterparties rated under investment grade, as they usually have higher probabilities of defaulting. The requirements from the BBB range from 5 107 371€ to 8 547 790€ under the conservative scenario and from 5 107 371€ to 8 547 790€ under the realistic scenario. From the BB counterparty even higher amounts are required. There exist also some minor requirements for the BB counterparty under the trust scenario but it does not have to deliver them since they are smaller than the minimum transfer amount applied to it, which in turn increases the exposure faced by the collateral receiver.

Again, the same pattern is observed at each time point when the financial institution is the collateral receiver, i.e. months 33-57. This observed pattern sheds additional light on the way

the independent, threshold and minimum transfer amounts work and what is their contribution to the residual counterparty risk related to collaterals. To sum up, although the independent, threshold and minimum transfer amounts are based on the counterparty rating, they work either to increase or decrease the exposure faced by the other counterparty. The higher the independent amount, the more collateral is required and the better the underlying exposure volatility is protected. The smaller the minimum transfer amount, the more often collateral has to be delivered and the better the exposure is reduced all the time. And finally, the lower the threshold, the larger the amount of exposure that is covered by the collateral. Thus, the collateral sufficiency evaluation with regard to exposure volatility is intertwined with these collateral determination amounts.

8.3 Evaluation of the effect of collateral riskiness on collateral requirement

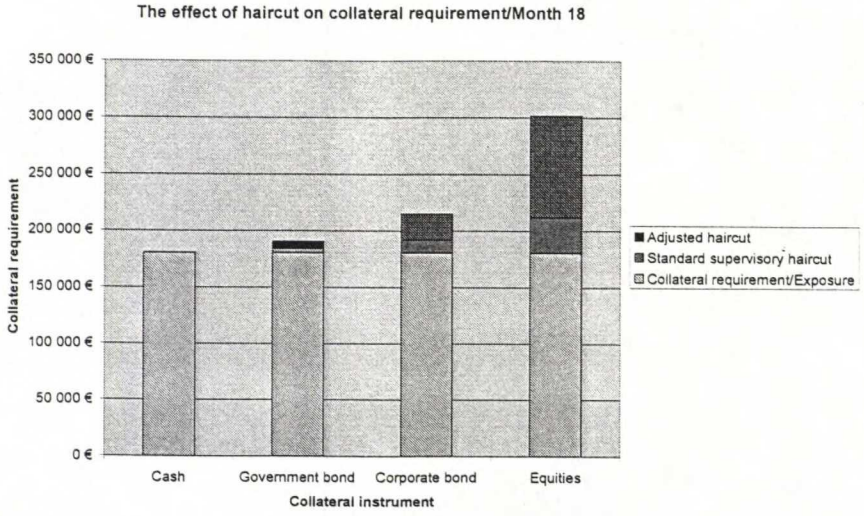
Riskiness of the collateral instrument is taken into account in collateral requirement determinations by applying a proper haircut. Thus the effects of the collateral instrument price volatility, low liquidity, issuer risk, residual time to maturity and holding period are incorporated into the collateral requirement. Undesired correlations are not necessarily reflected in the haircut level. The standard supervisory haircuts provided by Basel II are determined according to the instrument's rating and type, it's issuer risk and the remaining time to maturity. Thus the haircuts applied in this study reflect at least these aspects of collateral instruments. Again, the examples here are based on the case information given in Chapter 6 and example calculations are presented in Appendix D.

If the applied haircut is high enough and adjusted properly, if needed, changes in the contributors to collateral instrument riskiness should not have any effect on the residual counterparty risk. If, however, there is a larger change in the collateral riskiness than anticipated or there are strong undesired correlations, the collateral amount might turn out to be insufficient leading to residual counterparty risk. Thus the evaluation of the effect of the collateral riskiness on residual counterparty risk implies actually assessing the appropriateness of the haircut rate compared to the instrument volatility.

The effect of haircut on the collateral requirement is depicted in Graph 10. Month 18 under the conservative scenario with counterparty rated A is examined as an example. At month 18, the financial institution is the provider of the collateral.

Graph 10 The effect of the haircut on collateral requirement

Conservative scenario and A rated counterparty are used as an example and both standard supervisory haircuts and adjusted haircuts are shown



It can be seen from the graph that the riskier the collateral, the higher the amount of collateral that needs to be required. The lowest part of each of the pillars presents the collateral requirement without any haircut. In this case it corresponds to the expected exposure, as the independent amounts cancel out between A rated counterparties and no thresholds are applied. The upper parts of the pillars show the effect the haircut has on the requirement; the riskier the collateral instrument, the more has to be required. The standard supervisory haircut (99% confidence level, 10-day holding period) reflects the effect that the haircut would have without any adjustment to the real remargining period. The adjusted haircut in turn reflects the haircut amount adjusted to the real remargining period. In this case 180 300€ of cash, 201 979€ of government bond, 214 898€ of corporate bond or 301 754€ of equities collateral need to be delivered to counterparty rated A. Again, to sum up, the collateral sufficiency evaluation with regard to collateral volatility is intertwined with the evaluation of the haircut.

8.4 Evaluation of residual counterparty risk related to collaterals

Next, having presented the way the collateral determination amounts and haircuts work, the residual counterparty risk related to collaterals is evaluated. The collateral sufficiency with regard to exposure volatility and collateral instrument riskiness are treated separately.

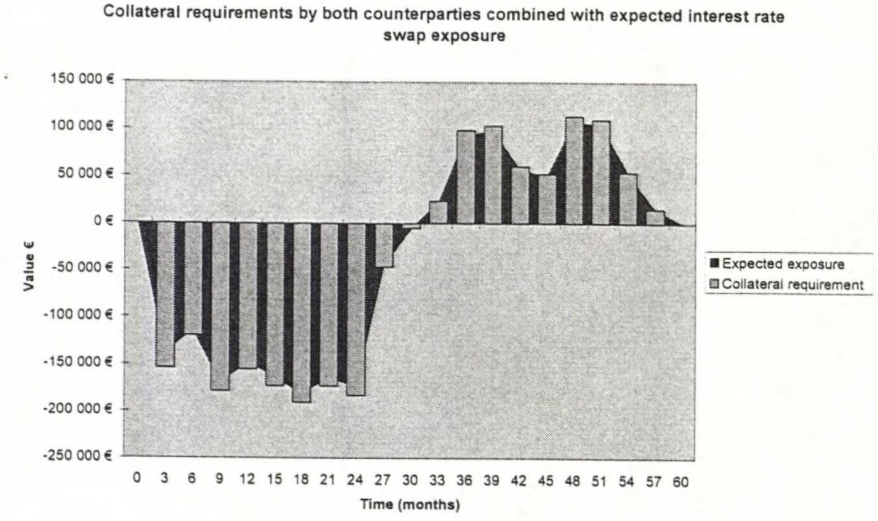
8.4.1 Exposure volatility and collateral volatility

In Graph 12, as an example of the effect that the collateral has on the exposure resulting from the interest rate swap, a contract with A rated counterparty with German government bond as collateral instrument under conservative scenario is presented. Graph 11 thus combines the

expected exposure of the swap and the German government bond collateral requirements as an example in the same picture.

Graph 11 The expected credit exposure of the 5-year swap and bond collateral requirements by both counterparties

German government bond collateral requirements by both A rated counterparty during time periods 3-30 and by financial institution during time periods 33-57 are shown together with the expected exposure under the conservative scenario



If the exposure profile of the interest rate swap follows the expected exposure values, implying that the term structures would be realized as expected at time zero and the collateral value would change only moderately, with the German government bond collateral, the exposure is always covered and there is even a possibility for overcollateralisation. This is because a minor haircut is applied to government bond. This is however necessary, as the price of the bond might change, and the required amount might thus not lead to overcollateralisation. Similarly, in other scenarios with other instruments and other counterparties, when collateral is required it is sufficient to cover the exposure and risk of overcollateralisation for collateral giver is present. However, collateral is not required in every counterparty-scenario combination and there are periods when no collateral would be required based on expected exposure.

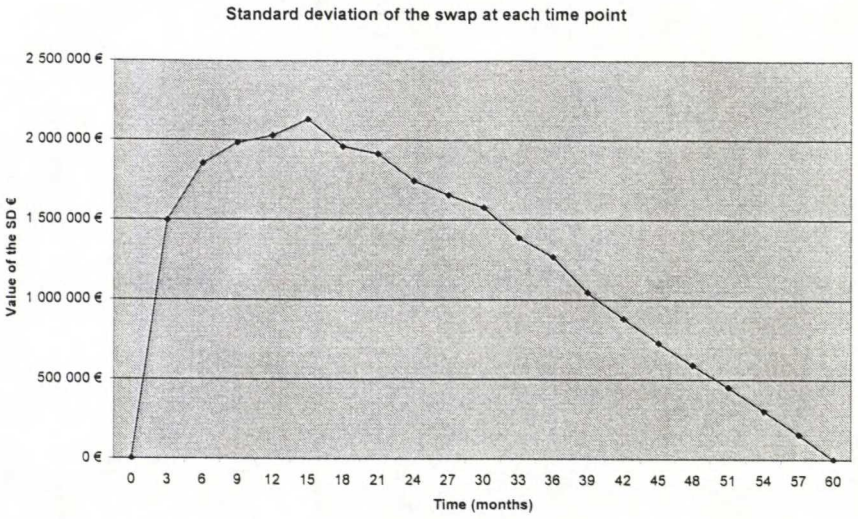
However, first of all, if the exposure value changes significantly after collateral is received, the collateral might turn out to be insufficient to cover the exposure during the whole effective exposure period. Secondly, if the collateral instrument value changes unexpectedly after collateral delivery, the collateral amount will not be large enough to cover the exposure. This risk is further amplified the longer the period between collateral calls. Thus, the exposure volatility and the collateral instrument volatility are examined next. Also possible correlations

between collateral instrument and the underlying exposure are evaluated at the end. Differing remargining periods are also used in calculations to reflect the effective exposure period.

Exposure volatility

As explained, the volatility of the swap value creates potential credit risk exposure in addition to the current exposure, i.e. the mark-to-market swap value. Graph 12 depicts the absolute implied standard deviation values of the interest rate swap through out its life. The standard deviation is expressed with three-month intervals.

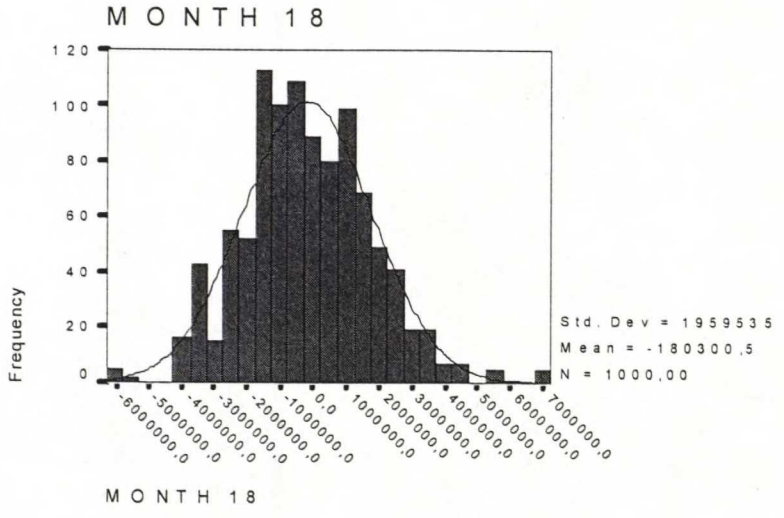
Graph 12 The implied three-month standard deviation (in Euros) of the 5-year interest rate swap at each time point (1000 simulations)



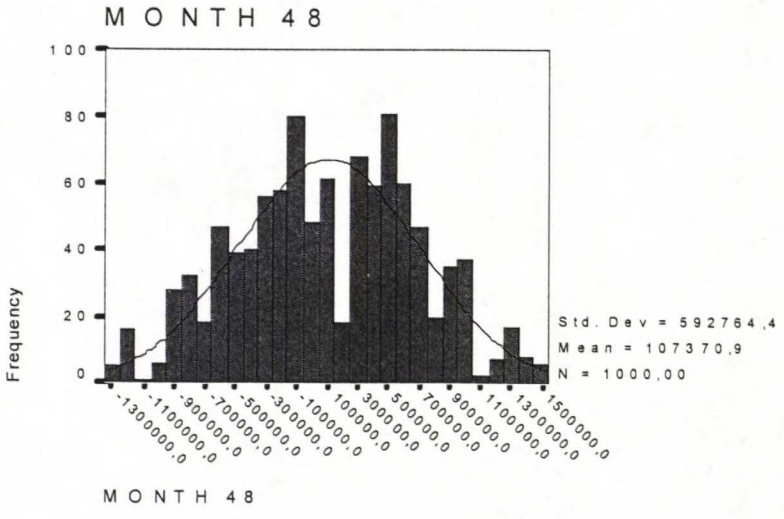
There are a few particularly interesting time points during the life of the interest rate swap. The first one is month 18, when the exposure for the counterparty would be at its highest and also the volatility is quite high. Thus the possibility for collateral insufficiency due to exposure volatility is relatively high and also the loss in the case of default would be severe. Another time point is month 48, when the exposure is at its highest for the financial institution, but the volatility has reduced and is significantly lower. Here, the potential for insufficient collateral is smaller, but the damage in case of default would still be rather large.

Graphs 13 and 14 show the distribution of the interest rate swap value around its expected mean at these two time points. Also the normal distribution function is displayed to reflect the fit of the distribution to the normal distribution. Other time points show similar distributions with decreasing volatility as the agreement matures. See Appendix E for other time points and their distributions.

Graph 13 Distribution of the value of the interest rate swap at time point 18 with normal distribution curve



Graph 14 Distribution of the value of the interest rate swap at time point 48 with normal distribution curve



The expected exposures at these time points are 180 300€ in month 18 and 107 370€ in month 48. The standard deviations of the interest rate swap values are 1 959 535€ and 592 764€. The difference in the volatilities between these two time points is clearly shown indicating decreasing volatility with maturity and the graphs also provide good examples of the volatility during both the out-of-the-money and in-the-money periods.

From the normal distribution functions it can be seen that normal approximation provides a rather good fit to the data, although it seems that the distributions have fat tales, at least in

some time periods. In fact, the Kolmogorov-Smirnov test of normality rejects the assumption of normal distribution in some cases (see Appendix F). The Jarque-Bera test of normality provides similar results. However, as it is shown in Appendix C, skewnesses of the distributions are close to zero, implying symmetric and thus normal distributions. Kurtosises, on the other hand, differ slightly from that assumed for normal distributions (i.e. 3, or excess kurtosis of 0), which explains why the normality is rejected in some cases. If the excess kurtosis figure is small, e.g. less than zero, it implies that the distribution has fat tails, i.e. there are observations with low probability of occurrence but with large values. The CaR-analysis performed later in this chapter is suitable for these distributions, but fat tails have to be taken into account in the analysis.

Collateral instrument volatility

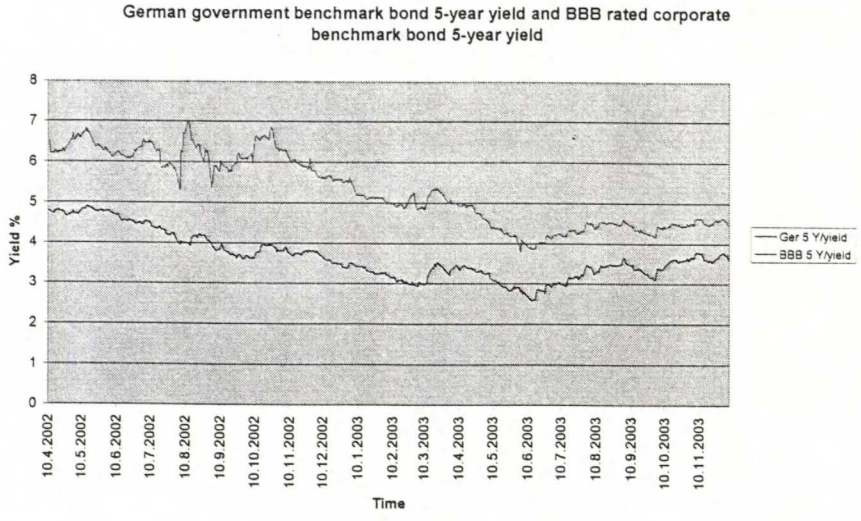
In addition to the exposure volatility of the interest rate swap, the volatilities of the collateral instruments need to be considered. Cash as collateral instrument is left out, as it is not volatile instrument. The evaluation of the volatilities is based on historical data that is chosen to reflect the collateral instruments and the swap as well as possible, as no specific data of the case collateral instruments is available. (See Chapter 6.3 for more details about the historical data.)

As the collaterals are usually valued at mid price (ISDA, 1998), the interest is in the price volatility of the instruments. Volatility of the bond instrument price is similar in nature as the volatility of the interest rate swap, as they are both interest rate based instruments. As the maturity decreases also the volatility of the bond decreases, implying that short bonds are less sensitive to changes in bond yield than longer bonds (see e.g. Luenberger, 1998). In other words, their price-yield curves are rather gently downward sloping. The price changes are a consequence of a change in the bond yield; if the yield goes up, the price of the bond goes down and vice versa. Thus, as no price information for the bonds is available, the price volatility can be inferred from the yields of the bonds with different maturities. The simple relationship between the change in the bond price and the change in the yield is achieved with the help of modified duration (see e.g. Luenberger, 1998) and the relationship can be used to approximate the price change and thus price volatility. The modified durations are calculated assuming that the bonds are selling at par, i.e. at 100, at all of the observation times, and thus

the yields and coupons of the bonds are identical[24]. Graph 15 shows the behaviour of the bonds during the historical observation period.

Graph 15 The behaviours of the German government benchmark bond and Eurozone BBB rated corporate benchmark bond during the historical observation period

The graph depicts 5-year yields of both bonds during the time period of 10.4.2002-5.12.2003

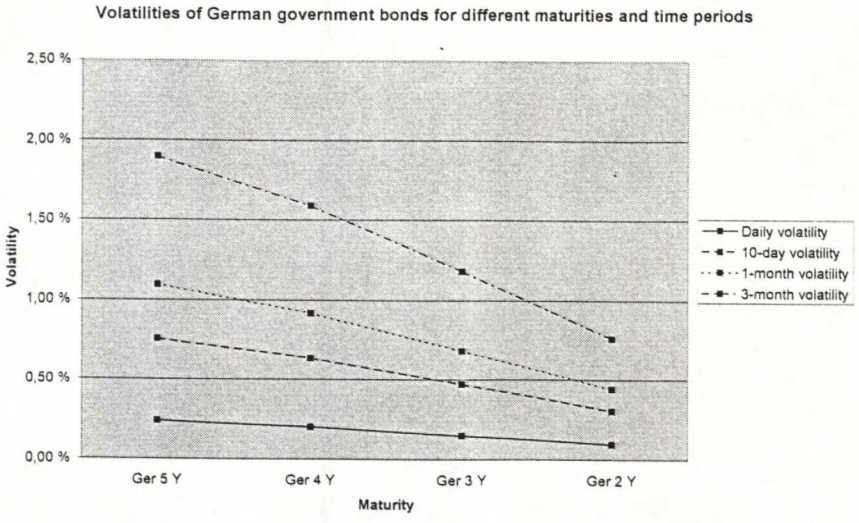


The graph shows how the Eurozone BBB rated corporate benchmark bond average 5-year yield has been more volatile than the German government benchmark bond 5-year yield. The daily volatilities of the BBB rated corporate benchmark bond 5-year yield and the German government benchmark bond 5-year yield have been 0,466% and 0,239%, respectively. However, these volatilities are true only for bonds with 5-year maturities. As stated above, the volatilities are not stable throughout different maturities. Graph 16 depicts the volatilities of the German government bond prices for different maturities and for different time periods.

[24] In reality, the coupon of the bond affects the duration of the bond. For the par bond the duration is longer than for the discount bond, but shorter than for the premium bond. However, for the purpose of estimating the volatilities, the calculations made based on the given assumptions give sufficiently good estimates.

Graph 16 Volatility of the German government benchmark bond price during the historical observation period

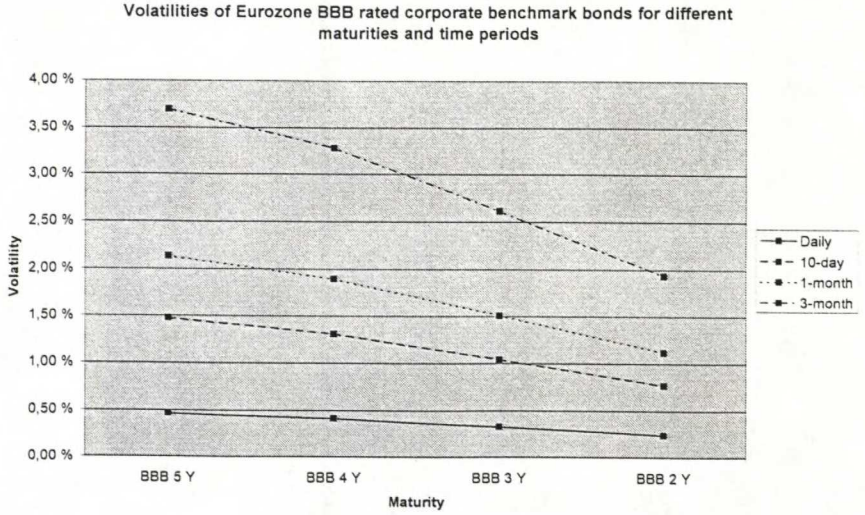
The graph depicts volatility of the bond for different maturities, i.e. 2-, 3-, 4- and 5-year bonds, and also for different time periods, i.e. one day, ten-day, one month and three-month volatilities, based on the period of 10.4.2002-5.12.2003



It can be seen from the graph that the daily volatilities have not changed much with maturity. The daily volatilities for the German government bond price have been between 0,10% and 0,24%, i.e. within 14 basis points, for the maturities between 2 and 5 years. Thus, it can be stated that the volatility of German government bond does not decrease much with maturity. Thus also the volatilities for other time periods, such as ten days, one month, three months and even one year, can be calculated using the simple square root of time –formula. The yearly volatilities of the German government 5-year and 2-year bonds have been 3,79% and 1,52%, respectively. Graph 17 depicts the same information for the Eurozone BBB rated benchmark corporate bonds. It can be assumed that the StoraEnso Oyj corporate bond behaves approximately the same way.

Graph 17 Volatility of the Eurozone BBB rated corporate benchmark bond price during the historical observation period

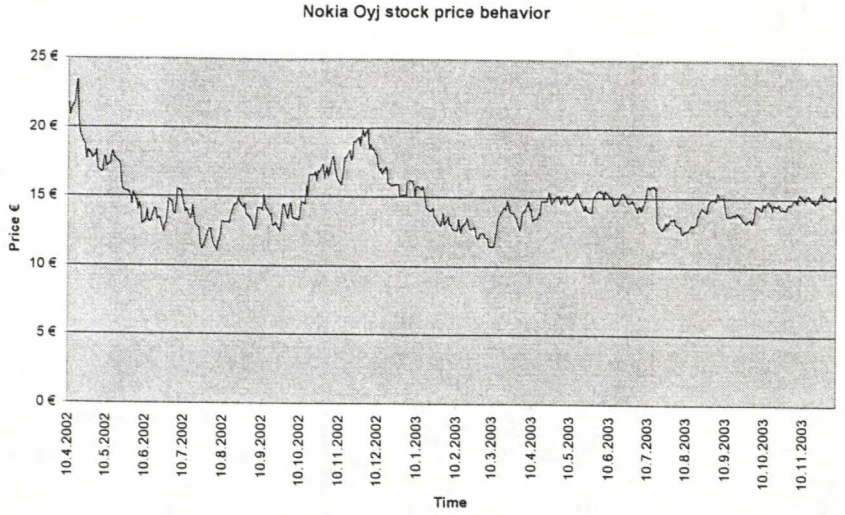
The graph depicts volatility of the bond for different maturities, i.e. 2-, 3-, 4- and 5-year bonds, and also for different time periods, i.e. one day, ten-day, one month and three-month volatilities, based on the period of 10.4.2002-5.12.2003



Similar interpretations can be drawn from the volatilities of the BBB rated corporate benchmark bond prices. The daily volatilities have varied between 0,24% and 0,47%, i.e. they have been within 23 basis points, for maturities of 2 years and 5 years, respectively. Daily volatilities have thus been rather similar independent of the maturity. Thus again, the daily volatilities can be deemed to be only slightly decreasing during the period the StoraEnso Oyj bond is used as collateral and the volatilities for longer periods can be calculated using square root of time –formula. Yearly volatilities have thus ranged between 7,39% and 3,87% for the 5-year and 2-year bonds, respectively. To sum up, the volatilities of both bonds have been at quite moderate levels and can be deemed as rather riskless collateral instruments in this respect.

The volatility of the Nokia Oyj stock is less complicated to determine. It can be inferred directly from the stock price variations and there is no similar connection between the time to maturity and the volatility of the stock as there is with bonds. Graph 18 depicts the price behaviour of the Nokia Oyj stock for the observation period.

Graph 18 The behaviour of the Nokia Oyj stock price during the historical observation period



The daily volatility of the Nokia Oyj stock during the sample period has been approximately 3,45% which indicates a yearly volatility of 54,75%. Thus it is the most volatile of all of the collateral instruments and thus presents high risk of being insufficient collateral.

8.4.2 Results of residual counterparty risk evaluation -exposure volatility

To evaluate the residual counterparty risk, the exposure volatility as a contributor to this risk is examined first. In the next chapter, the collateral instrument riskiness, in the form of volatility and undesired correlations is studied.

8.4.2.1 95% CaR-analysis

To assess the exposure volatility and to estimate the collateral sufficiency, VaR-figures, or more precisely Credit at Risk, i.e. CaR, figures (see e.g. Dowd, 1998; Jorion, 2001) with 95% confidence level are calculated for each time period based on normal distribution assumption. CaR is the largest credit exposure at some confidence level over certain time period. The CaR is calculated for four different remargining periods, namely three months, one month, ten days and one day to see the effect of the gap between collateral calls. The credit at risk at the 95% confidence level is

$$CaR = \mu_t \pm 1.65\sigma_t \qquad (3)$$

where

μ_t is the expected exposure at each time point;

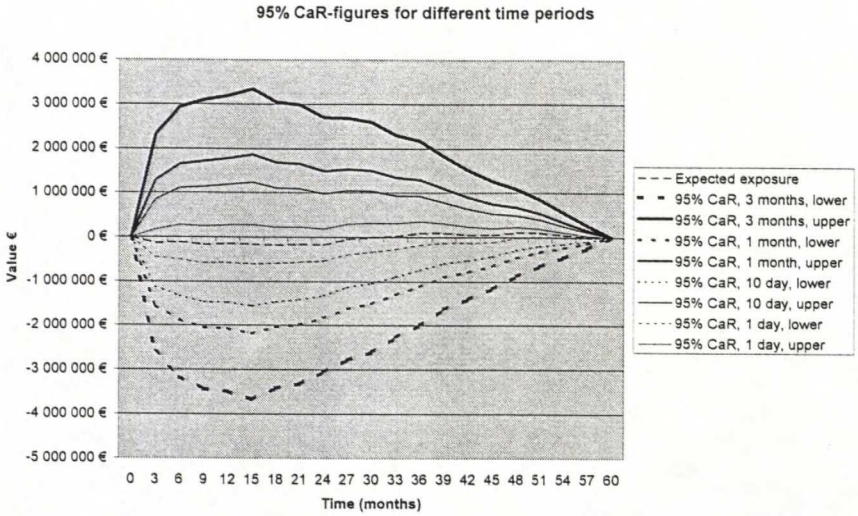
σ_t is the implied standard deviation, i.e. the implied volatility of the exposure at each time point; and

t=3, 6, 9, … ,57

Graph 19 depicts these CaR-values for the interest rate swap for the entire life of the swap agreement.

Graph 19 95% Credit at Risk -figures for the interest swap exposure, upper and lower bounds

The graph shows the 95% CaR's over 3-month, 1-month, 10-day and 1-day periods, both tails of the distribution are shown



Only the downward deviations of market values are considered between months 3 and 30. This is because the expected value of the swap is negative during this period and only lower values of the exposure increase the risk for the collateral receiver. Thus for the period when the financial institution is the provider of the collateral and it has negative exposure, the left tail of the distribution is considered.

On the other hand, only the upward deviations of market values are considered between months 33 and 57. During this period upward movements increase the risk faced by the collateral receiver. When the financial institution is the collateral receiver, i.e. it is in-the-money, the right tale of the distribution is considered. If the value changes to opposite directions in both periods, the counterparty risk would only decrease. Thus in each case only one-tailed confidence levels are considered.

Next, the CaR-figures, i.e. the worst credit exposures over different time periods with 95% confidence level are compared to the collateral requirements under each scenario to evaluate

the sufficiency of the collateral requirement. Only counterparties with which collateral requirements exist are examined.

8.4.2.2 Conservative scenario

Under this scenario AA and A rated counterparties would require collateral from the financial institution and the institution would in turn require collateral from A, BBB and BB rated counterparties. All of the counterparties are thus examined under this scenario. The independent, threshold and minimum transfer amounts applicable for each scenario were presented in Chapter 6.1.2.

Table 8 tabulates the expected exposure and standard deviation of the swap for each period, emphasising time points 18 and 48, and all of the CaR-figures calculated. It also tabulates the cash and equities collateral requirements, as two extremes of the requirements, by the AA rated counterparty between months 3 and 30 and the requirements by the financial institution between months 33 and 57.

Month	Expected exposure	Implied SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP AA, cash	CP AA, equities
3	-137 412€	1 497 418€	2 608 152€	1 563 894€	1 121 778€	448 696€	2 137 412€	3 577 212€
6	-112 919€	1 853 462€	3 171 132€	1 878 579€	1 331 340€	498 218€	2 112 919€	3 536 220€
9	-168 737€	1 982 478€	3 439 826€	2 057 301€	1 471 970€	580 856€	2 168 737€	3 629 639€
12	-146 817€	2 028 569€	3 493 955€	2 079 288€	1 480 348€	568 516€	2 146 817€	3 592 952€
15	-163 416€	2 129 728€	3 677 467€	2 192 254€	1 563 447€	606 145€	2 163 416€	3 620 732€
18	**-180 301€**	**1 959 535€**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**2 180 301€**	**3 648 991€**
21	-163 628€	1 913 591€	3 321 054€	1 986 569€	1 421 577€	561 426€	2 163 628€	3 621 088€
24	-172 899€	1 745 304€	3 052 651€	1 835 525€	1 320 220€	535 714€	2 172 899€	3 636 604€
27	-44 017€	1 657 334€	2 778 619€	1 622 840€	1 133 508€	388 544€	2 044 017€	3 420 904€
30	-4 732€	1 577 514€	2 607 630€	1 507 516€	1 041 751€	332 666€	2 004 732€	3 355 156€
33	22 654€	1 387 739€	2 312 423€	1 344 653€	934 920€	311 138€	0€	0€
36	93 305€	1 266 211€	2 182 553€	1 299 533€	925 681€	356 526€	0€	0€
39	97 757€	1 104 465€	1 824 424€	1 094 649€	785 678€	315 296€	0€	0€
42	57 064€	882 268€	1 512 806€	897 537€	637 046€	240 470€	0€	0€
45	49 772€	732 012€	1 257 592€	747 107€	530 979€	201 943€	0€	0€
48	**107 371€**	**592 764€**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**0€**	**0€**
51	103 996€	452 909€	851 297€	535 450€	401 728€	198 147€	0€	0€
54	53 353€	303 399€	553 961€	342 379€	252 800€	116 424€	0€	0€
57	15 116€	155 554€	271 779€	163 300€	117 373€	47 452€	0€	0€

Table 8 Expected exposure, standard deviations and 95% CaR-figures with collateral requirements with AA rated counterparty

The table depicts 95% CaR's over three-month, one month, ten-day and one day time periods for time periods from 3 to 57 with cash and equities collateral requirements under the conservative scenario

The CaR –figures show that the swap exposure values can actually be a lot higher than what the expected exposure indicates. In time period 18, for example, there is a 5% possibility that

the value is higher than 3 413 534€ over the next three months, higher than 2 047 009€ over the next month, higher than 1 468 452 € over the next ten days or 587 650€ over the next day. The respective figures for the month 48 are 1 085 432€ over the next three months, 672 055€ over the next month, 497 040€ over the next ten days and 230 595€ over the next day. This analysis shows that the value of the exposure varies considerably and because of adverse movements in the value, the collateral may turn out to be insufficient.

The collateral posted by the financial institution to the AA rated counterparty would generally be sufficient to cover the worst exposure calculated for one-month (except month 15), ten-day and one-day periods. This implies that if within one month, ten days or one day, the exposure value changes to the value indicated by the respective CaR-figure, the collateral required would still cover the exposure. Thus the risk to face insufficient collateral and thus residual counterparty risk in this case is minimal. However, within three- month horizon, the collateral requirement might turn out to be insufficient. It should be noted, nevertheless, that three-month intervals for collateral calls are rare in practice; more frequent than monthly are true in practice. The reason why collateral requirements are so high and would thus cover maximum exposures is that a higher independent amount is applied to the A rated counterparty than to the AA rated counterparty and it buffers against the exposure volatility. It should be noted that during this period the financial institution might as well be posting too much collateral facing thus risks related to overcollateralisation. If the exposure value does not change so drastically, more collateral is posted than needed and if the collateral receiver defaults, collateral instrument or part of it could be lost.

However, after month 33, when the financial institution would be entitled to require collateral, it would not, based on the expected exposure value, and thus it faces counterparty risk. This is due to the fact that the independent amount applied to the AA rated counterparty is lower and would not trigger collateral call. During this period, possibility to face losses is high as no collateral is used. However, the counterparty is rated AA and it's probability of default is only 0,27% within next five years. Table 9 presents the same risk figures and collateral requirements for a situation where the counterparty is rated at A.

Month	Expected exposure	SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP A, cash	CP A, equities
3	-137 412€	1 497 418 €	2 608 152 €	1 563 894€	1 121 778€	448 696€	137 412€	229 975€
6	-112 919€	1 853 462 €	3 171 132 €	1 878 579€	1 331 340€	498 218€	112 919€	188 984€
9	-168 737€	1 982 478 €	3 439 826 €	2 057 301€	1 471 970€	580 856€	168 737€	282 402€
12	-146 817€	2 028 569 €	3 493 955€	2 079 288€	1 480 348€	568 516€	146 817€	245 715€
15	-163 416€	2 129 728 €	3 677 467€	2 192 254€	1 563 447€	606 145€	163 416€	273 496€
18	**-180 301€**	**1 959 535 €**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**180 301€**	**301 754€**
21	-163 628€	1 913 591 €	3 321 054€	1 986 569€	1 421 577€	561 426€	163 628€	273 851€
24	-172 899€	1 745 304 €	3 052 651€	1 835 525€	1 320 220€	535 714€	172 899€	289 367€
27	-44 017€	1 657 334 €	2 778 619€	1 622 840€	1 133 508€	388 544€	44 017€	73 668€
30	-4 732€	1 577 514 €	2 607 630€	1 507 516€	1 041 751€	332 666€	4 732€	7 919€
33	22 654€	1 387 739 €	2 312 423€	1 344 653€	934 920€	311 138€	22 654€	37 914€
36	93 305€	1 266 211 €	2 182 553€	1 299 533€	925 681€	356 526€	93 305€	15 657€
39	97 757€	1 104 465 €	1 824 424€	1 094 649€	785 678€	315 296€	97 757€	163 608€
42	57 064€	882 268 €	1 512 806€	897 537€	637 046€	240 470€	57 064€	95 503€
45	49 772€	732 012 €	1 257 592€	747 107€	530 979€	201 943€	49 772€	83 299€
48	**107 371€**	**592 764 €**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**107 371€**	**179 698€**
51	103 996€	452 909 €	851 297€	535 450€	401 728€	198 147€	103 996€	174 050€
54	53 353€	303 399 €	553 961€	342 379€	252 800€	116 424€	53 353€	89 293€
57	15 116€	155 554 €	271 779€	163 300€	117 373€	47 452€	15 116€	25 298€

Table 9 Expected exposure, standard deviations and 95% CaR -figures with collateral requirements with A rated counterparty

The table depicts 95% CaR's over three-month, one month, ten-day and one day time periods for time periods from 3 to 57 with cash and equities collateral requirements under the conservative scenario

As it can be seen from the table, the collateral requirements are insufficient to cover the possibility of unexpected changes in value at each time point. The requirements vary from 180 301€ to 301 754€ in month 18 and from 107 371€ to 179 698€ in month 48. In this scenario independent amounts are used but as both counterparties have the same rating and independent amount is the same for both, they cancel out and thus provide no buffer against the exposure volatility. Hence, dissimilar independent amounts between counterparties would actually provide better cover. Thus during the first 30 months, due to the exposure volatility, the A rated counterparty might suffer from insufficient collateral and if the financial institution were to default the A rated counterparty would not probably be fully covered from losses. The same is true for the rest of the contract period, this time the financial institution faces the same risk. No risk for overcollateralisation exists.

However, if the collateral sufficiency is examined further, in a situation where the counterparty has a lower rating, namely BBB, the collateral requirements turn out to be sufficient again. Table 10 depicts again the risk figures and collateral requirements for each month with BBB rated counterparty, emphasising months 18 and 48.

Month	Expected exposure	SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP BBB, cash	CP BBB, equities
3	-137 412€	1 497 418 €	2 608 152 €	1 563 894€	1 121 778€	448 696€	0 €	0 €
6	-112 919€	1 853 462 €	3 171 132 €	1 878 579€	1 331 340€	498 218€	0 €	0 €
9	-168 737€	1 982 478 €	3 439 826 €	2 057 301€	1 471 970€	580 856€	0 €	0 €
12	-146 817€	2 028 569 €	3 493 955€	2 079 288€	1 480 348€	568 516€	0 €	0 €
15	-163 416€	2 129 728 €	3 677 467€	2 192 254€	1 563 447€	606 145€	0 €	0 €
18	**-180 301€**	**1 959 535 €**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**0 €**	**0 €**
21	-163 628€	1 913 591 €	3 321 054€	1 986 569€	1 421 577€	561 426€	0 €	0 €
24	-172 899€	1 745 304 €	3 052 651€	1 835 525€	1 320 220€	535 714€	0 €	0 €
27	-44 017€	1 657 334 €	2 778 619€	1 622 840€	1 133 508€	388 544€	0 €	0 €
30	-4 732€	1 577 514 €	2 607 630€	1 507 516€	1 041 751€	332 666€	0 €	0 €
33	22 654€	1 387 739 €	2 312 423€	1 344 653€	934 920€	311 138€	5 022 654 €	8 406 006 €
36	93 305€	1 266 211 €	2 182 553€	1 299 533€	925 681€	356 526€	5 093 305 €	8 524 249 €
39	97 757€	1 104 465 €	1 824 424€	1 094 649€	785 678€	315 296€	5 097 757 €	8 531 670 €
42	57 064€	882 268 €	1 512 806€	897 537€	637 046€	240 470€	5 057 064 €	8 463 595 €
45	49 772€	732 012 €	1 257 592€	747 107€	530 979€	201 943€	5 049 772 €	8 451 392 €
48	**107 371€**	**592 764 €**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**5 107 371 €**	**8 547 790 €**
51	103 996€	452 909 €	851 297€	535 450€	401 728€	198 147€	5 103 996 €	8 542 142 €
54	53 353€	303 399 €	553 961€	342 379€	252 800€	116 424€	5 053 353 €	8 457 385 €
57	15 116€	155 554 €	271 779€	163 300€	117 373€	47 452€	5 015 116 €	8 393 390 €

Table 10 Expected exposure, standard deviations and 95% CaR -figures with collateral requirements with BBB rated counterparty

The table depicts 95% CaR's over three-month, one month, ten-day and one day time periods for time periods from 3 to 57 with cash and equities collateral requirements under the conservative scenario

However, this sufficiency is only true for the period when the collateral is required by the financial institution, namely months 33-57. During the first three years of the contract the BBB rated counterparty does not require any collateral from the financial institution, based on the expected exposure value, thus posing itself to counterparty risk. The collateral requirements by the financial institution from the BBB counterparty are sufficient to cover even the exposures calculated with 95% CaR and three month holding period. This is because a rather high independent amount is applied to the BBB rated counterparty. It adds to the collateral requirement and thus buffers against exposure volatility, as intended. However, again the collateral giver, this time the BBB rated counterparty faces the risk of overcollateralisation. Collateral amounts required from the BB rated counterparty are even higher under this scenario, ranging approximately form 10 000 000€ to almost 17 000 000€ at every time point, and they would also cover the exposure volatilities but would expose the BB rated counterparty to high overcollateralisation risk. The figures related to BB rated counterparty are not tabulated here; see Appendix G for the figures.

8.4.2.3 Realistic scenario

Under the realistic scenario the financial institution does not have to post any collateral to its counterparties during the first 30 months of the agreement. Thus the counterparties assume high counterparty risk without any cushion. When the financial institution is entitled to require collateral, it requires collateral only from its BBB and BB rated counterparties. Thus, under the realistic scenario, the focus will be on the BBB and BB rated counterparties. Table 11 tabulates again the risk figures and collateral requirements, this time under the realistic scenario and with BBB rated counterparty.

Month	Expected exposure	SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP BBB, cash	CP BBB, equities
3	-137 412€	1 497 418 €	2 608 152 €	1 563 894€	1 121 778€	448 696€	0 €	0 €
6	-112 919€	1 853 462 €	3 171 132 €	1 878 579€	1 331 340€	498 218€	0 €	0 €
9	-168 737€	1 982 478 €	3 439 826 €	2 057 301€	1 471 970€	580 856€	0 €	0 €
12	-146 817€	2 028 569 €	3 493 955€	2 079 288€	1 480 348€	568 516€	0 €	0 €
15	-163 416€	2 129 728 €	3 677 467€	2 192 254€	1 563 447€	606 145€	0 €	0 €
18	**-180 301€**	**1 959 535 €**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**0 €**	**0 €**
21	-163 628€	1 913 591 €	3 321 054€	1 986 569€	1 421 577€	561 426€	0 €	0 €
24	-172 899€	1 745 304 €	3 052 651€	1 835 525€	1 320 220€	535 714€	0 €	0 €
27	-44 017€	1 657 334 €	2 778 619€	1 622 840€	1 133 508€	388 544€	0 €	0 €
30	-4 732€	1 577 514 €	2 607 630€	1 507 516€	1 041 751€	332 666€	0 €	0 €
33	22 654€	1 387 739 €	2 312 423€	1 344 653€	934 920€	311 138€	5 022 654 €	8 406 006 €
36	93 305€	1 266 211 €	2 182 553€	1 299 533€	925 681€	356 526€	5 093 305 €	8 524 249 €
39	97 757€	1 104 465 €	1 824 424€	1 094 649€	785 678€	315 296€	5 097 757 €	8 531 670 €
42	57 064€	882 268 €	1 512 806€	897 537€	637 046€	240 470€	5 057 064 €	8 463 595 €
45	49 772€	732 012 €	1 257 592€	747 107€	530 979€	201 943€	5 049 772 €	8 451 392 €
48	**107 371€**	**592 764 €**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**5 107 371 €**	**8 547 790 €**
51	103 996€	452 909 €	851 297€	535 450€	401 728€	198 147€	5 103 996 €	8 542 142 €
54	53 353€	303 399 €	553 961€	342 379€	252 800€	116 424€	5 053 353 €	8 457 385 €
57	15 116€	155 554 €	271 779€	163 300€	117 373€	47 452€	5 015 116 €	8 393 390 €

Table 11 Expected exposure, standard deviations and 95% CaR-figures with collateral requirements with BBB rated counterparty

The table depicts 95% CaR's over three-month, one month, ten-day and one day time periods for time periods from 3 to 57 with cash and equities collateral requirements under the realistic scenario

The collateral required from the BBB rated counterparty in this scenario are exactly the same as under the conservative scenario. Thus the analysis is also the same as in the previous scenario: collateral requirements are sufficient to cover the exposure between months 33 and 57. The required collateral would cover even the maximum credit exposures over three-month period. The risk of overcollateralisation for the collateral giver is however present. Again, the collateral amounts required from the BB counterparty are even higher and would again cover the maximum exposure values. The figures are identical to the figures under the conservative scenario.

8.4.2.4 Trust scenario

Under this scenario, again, based on the expected exposure values, the financial institution does not have to post any collateral to its counterparties during the first 30 months of the agreement. When the financial institution is entitled to require collateral, it requires collateral only from its BB rated counterparty. Thus, under the trust scenario, the focus will be on the BB rated counterparty only. Table 12 tabulates the risk figures and collateral requirements under the trust scenario with the BB rated counterparty.

Month	Expected exposure	SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP BB, cash	CP BB, equities
3	-137 412€	1 497 418 €	2 608 152 €	1 563 894€	1 121 778€	448 696€	0 €	0 €
6	-112 919€	1 853 462 €	3 171 132 €	1 878 579€	1 331 340€	498 218€	0 €	0 €
9	-168 737€	1 982 478 €	3 439 826 €	2 057 301€	1 471 970€	580 856€	0 €	0 €
12	-146 817€	2 028 569 €	3 493 955€	2 079 288€	1 480 348€	568 516€	0 €	0 €
15	-163 416€	2 129 728 €	3 677 467€	2 192 254€	1 563 447€	606 145€	0 €	0 €
18	**-180 301€**	**1 959 535 €**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**0 €**	**0 €**
21	-163 628€	1 913 591 €	3 321 054€	1 986 569€	1 421 577€	561 426€	0 €	0 €
24	-172 899€	1 745 304 €	3 052 651€	1 835 525€	1 320 220€	535 714€	0 €	0 €
27	-44 017€	1 657 334 €	2 778 619€	1 622 840€	1 133 508€	388 544€	0 €	0 €
30	-4 732€	1 577 514 €	2 607 630€	1 507 516€	1 041 751€	332 666€	0 €	0 €
33	22 654€	1 387 739 €	2 312 423€	1 344 653€	934 920€	311 138€	22 654€	37 914€
36	93 305€	1 266 211 €	2 182 553€	1 299 533€	925 681€	356 526€	93 305€	156 157€
39	97 757€	1 104 465 €	1 824 424€	1 094 649€	785 678€	315 296€	97 757€	163 608€
42	57 064€	882 268 €	1 512 806€	897 537€	637 046€	240 470€	57 064€	95 503€
45	49 772€	732 012 €	1 257 592€	747 107€	530 979€	201 943€	49 772€	83 299€
48	**107 371€**	**592 764 €**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**107 371€**	**179 698€**
51	103 996€	452 909 €	851 297€	535 450€	401 728€	198 147€	103 996€	174 050€
54	53 353€	303 399 €	553 961€	342 379€	252 800€	116 424€	53 354€	89 293€
57	15 116€	155 554 €	271 779€	163 300€	117 373€	47 452€	15 116€	25 298€

Table 12 Expected exposure, standard deviations and 95% CaR-figures with collateral requirements with BB rated counterparty

The table depicts 95% CaR's over three-month, one month, ten-day and one day time periods for time periods from 3 to 57 with cash and equities collateral requirements under the trust scenario

It can be seen form the table that the collateral requirements would not be sufficient. This case resembles the situation in which the contract is agreed with the A rated counterparty and the scenario is the conservative scenario. In this case there are no requirements between months 3 and 30 and the BB rated counterparty faces maximum amount of counterparty risk. After month 33, when the financial institution starts to require collateral, the collateral requirement amounts are close to the expected exposure value. This is because no threshold amount is applied to the BB rated counterparty and no independent amounts are set. Thus the requirement is close to the exposure and there is no buffer against exposure volatility. In addition, all of the requirements are under the minimum transfer amount applied to the BB

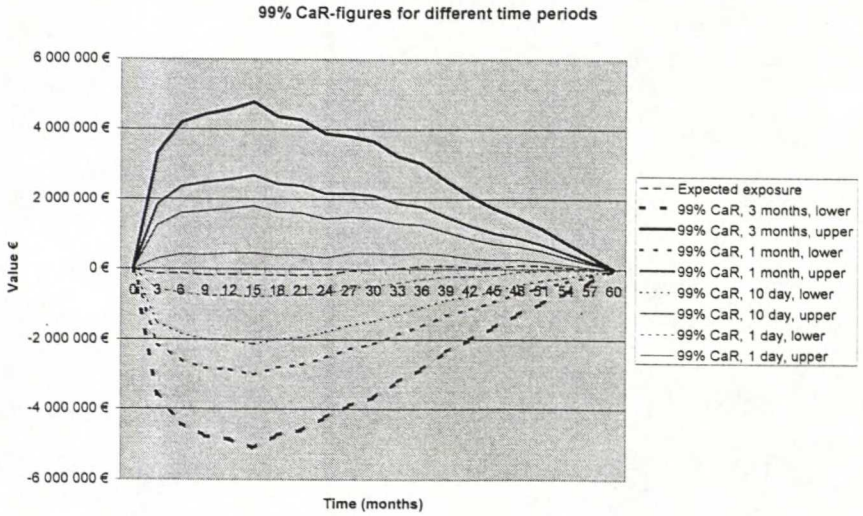
rated counterparty, thus no collateral would actually be delivered leaving the financial institution exposed. No risk of overcollateralisation is present.

8.4.2.5 99% CaR-analysis

As it was stated earlier in this chapter, in Chapter 8.4.1, the distributions of the swap values at each time point show fat tails. This affects significantly the analysis of the CaR-figures. Fat tails indicate that the CaR –figures calculated with the 95% confidence level could give a misleading view of the possible maximum credit exposures. As the fat tales indicate that there are observations with low probabilities but high values, it means that only a small change in the confidence level used in the CaR- analysis could lead to a significantly higher Credit at Risk figures. Thus also the 99% CaR-figures are calculated and presented here together with the previously calculated 95% CaR-figures. Graph 20 first depicts the CaR figures with 99% confidence level as a function of time for different time periods.

Graph 20 99% Credit at Risk -figures for the interest swap exposure, upper and lower bounds

The graph shows the 99% CaR's over 3-month, 1-month, 10-day and 1-day periods, both tails of the distribution are shown



The graph shows that the CaR –figures calculated with the higher 99% confidence level are actually a great deal higher than the CaR –figures with 95% confidence level. For example, the worst exposures over the three month period are well over 4 000 000€, both the upper and lower bounds with 99% confidence level. With 95% confidence level the worst credit exposures over three month period were less than 4 000 000€ (see also Graph 19). The same applies to other periods over which the CaR-figures are calculated. Thus it should be noted that in the previous chapter the figures were presented with 95% confidence level implying

that those extreme exposures could occur in five cases out of 100 or in one out of 20. However, with 99% confidence or in one case out of 100 these extreme exposure figures could be even higher. Hence, it is to be noted that the swap value distributions with fat tails imply that even though there are only a small probability of occurrence, the swap value can in rare cases deviate to very high values and thus increase the exposure to high levels. If that were to happen, the collateral could turn out to be severely insufficient. Table 13 presents the exact figure for both 95% and 99% CaR's.

Month	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	99% CaR, 3 months	99% CaR, 1 month	99% CaR, 10 days	99% CaR, 1 day
3	2 608 152 €	1 563 894€	1 121 778€	448 696€	3 611 422€	2 143 132€	1 521 490€	575 096€
6	3 171 132 €	1 878 579€	1 331 340€	498 218€	4 412 951€	2 595 544e	1 826 093€	654 672
9	3 439 826 €	2 057 301€	1 471 970€	580 856€	4 768 087€	2 824 173€	2 001 162€	748 201€
12	3 493 955€	2 079 288€	1 480 348€	568 516€	4 853 096€	2 863 988€	2 021 843€	739 752€
15	3 677 467€	2 192 254€	1 563 447€	606 145€	5 104 385€	3 016 086€	2 131 945€	785 919€
18	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**4 726 423€**	**2 805 005€**	**1 991 519€**	**753 058€**
21	3 321 054€	1 986 569€	1 421 577€	561 426€	4 603 161€	2 726 794€	1 932 380€	722 957€
24	3 052 651€	1 835 525€	1 320 220€	535 714€	4 222 005€	2 510 651€	1 786 101€	683 038€
27	2 778 619€	1 622 840€	1 133 508€	388 544€	3 889 033€	2 263 938€	1 575 908€	528 443€
30	2 607 630€	1 507 516€	1 041 751€	332 666€	3 664 564€	2 117 737€	1 462 844€	465 827€
33	2 312 423€	1 344 653€	934 920€	311 138€	3 242 208€	1 881 464€	1 305 355€	428 279€
36	2 182 553€	1 299 533€	925 681€	356 526€	3 030 914€	1 789 335€	1 263 677€	463 409€
39	1 824 424€	1 094 649€	785 678€	315 296€	2 525 556€	1 499 447€	1 065 015€	403 631€
42	1 512 806€	897 537€	637 046€	240 470€	2 103 926€	1 238 820€	872 553€	314 944€
45	1 257 592€	747 107€	530 979€	201 943€	1 748 040€	1 030 268€	726 378€	263 734€
48	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	**1 482 584€**	**901 351€**	**655 269€**	**280 631€**
51	851 297€	535 450€	401 728€	198 147€	1 154 746€	710 647€	522 625€	236 378€
54	553 961€	342 379€	252 800€	116 424€	757 238€	459 741€	333 788€	142 035€
57	271 779€	163 300€	117 373€	47 452€	376 000€	223 472€	158 895€	60 583€

Table 13 95% and 99% CaR -figures

The table depicts 95% and 99% CaR's over three-month, one month, ten-day and one day time periods, between months 3 and 30 only the lower bounds for CaR's are presented and between 33 and 57 only the higher bounds are tabulated

In general, the 99% CaR-figures are approximately 40% higher than the 95% CaR –figures. Thus the change in the confidence level yields about 40% higher worst credit exposures within the given time periods. The change is even higher for the daily CaR's. Thus, if collateral sufficiency is evaluated with the help of CaR-analysis or otherwise with the help of the possible swap value distribution, fat tails with high exposures but only limited possibility of occurrence need to be taken into account.

8.4.3 Results of residual counterparty risk evaluation –collateral instrument volatility and correlations

In this part of the study, the collateral instrument riskiness, and more specifically the volatility of the instrument and correlation with the interest rate swap, is examined. In this analysis it is assumed that the other contributors to collateral riskiness, such as collateral liquidity, issuer creditworthiness and correlation with collateralised counterparty remain stable throughout the swap contract. The reason is that the liquidity problem of the collateral is actually realised only when collateral has to be realised and thus the effects of liquidity could only be seen in the event of default. Change in issuer rating would mean change in the collateral determination amounts, which is implicitly taken into account in differing scenarios. No assumptions about probabilities of default of the counterparty are incorporated in the exposure calculations. And the correlation between collateral and the collateralised counterparty is mainly due to the line of business on which they operate and they are clearly assumed to remain stable and no significant correlations should exist. Thus only collateral instrument volatility and correlation with underlying exposure are examined as contributors to collateral riskiness.

8.4.3.1 Collateral instrument volatility

As it was stated in section 8.4.1, daily volatilities of the collateral bonds have been only slightly decreasing between long and short maturities. Naturally, the remaining time to maturity of the bond decreases as it is used as collateral. Thus the volatility decreases somewhat as the collateral instrument matures. German government bond is assumed to be acquired when the remaining time to maturity is about 5,5 years. Thus the interesting volatility is the volatility of the 5-year German government bond. Similarly, as the remaining time to maturity for the StoraEnso Oyj corporate bond is 3,5 years when acquired the relevant volatility is the 3-year bond volatility. In the beginning, haircuts are applied according to these remaining time to maturities. Later, when the bonds mature and the remaining maturities get shorter, and thus volatilities get lower, also lower haircuts are used. Thus volatilities for shorter bonds are of interest then. For the stock collateral, the volatility does not change with 'maturity' and the same daily volatility can be assessed through out the time it is used as collateral. It should be noted, however, that the volatilities used here are only historical volatilities for the chosen instruments and do not take into account possible changes in volatility in the future.

Recall that Basel II standard supervisory haircuts are calculated assuming ten-day holding period and 99% confidence level for capital market driven transactions, such as OTC derivatives. The ten-day holding period is based on the assumption of daily remargining. The haircuts applied and the volatilities of the collateral instruments through out the interest rate swap life can be compared to evaluate the collateral sufficiency. Volatilities can be compared to the haircuts set on the instruments by transforming the ten-day volatilities to correspond 99% confidence level.

The unadjusted standard supervisory haircuts used for the collateral instruments during the time they are used as collateral are presented once more in Table 14 (see Chapter 6.1.3.). Also the ten-day volatilities and ten-day volatilities adjusted to reflect 99% confidence level are tabulated. Volatilities for the bonds with maturity less than one year are not tabulated due to lack of data. However, they can be assumed to be lower than the volatilities for e.g. two-year bonds.

Collateral instrument	Remaining time to maturity	Standard supervisory haircut	Ten-day volatility	99% conf. level ten day volatility
Cash	-	0%	-	-
German government bond	> 5 years	4%	0,76%	1,76%
	1-5 years	2%	0,30-0,63%	0,71-1,48%
	< 1 year	0,5%	na	na
StoraEnso Oyj corporate bond	1-5 years	6%	0,77-1,31%	1,80-3,05%
	< 1 year	2%	na	na
Nokia Oyj equities	-	15%	10,91%	25,41%

Table 14 Collateral instruments, applied standard supervisory haircuts and collateral instrument volatilities

The table shows the standard supervisory haircuts assuming 10-day holding period and 99% confidence level, collateral instrument ten-day volatilities and 99% confidence level ten-day volatilities

The table shows that the volatilities of the bonds during a ten-day period are well lower than the haircuts applied to these instruments. This would indicate that at least during a ten-day period the prices of these bonds should not change on average more than what the volatility indicates and thus the haircut would be suitable to protect against price changes. However, for the Nokia Oyj stock, the volatility is higher than the applied haircut, indicating a possibility for high deviations in collateral value that are not protected by haircut. Thus with bond

collaterals, possibility for insufficient collateralisation is minimum, but with equities, such risk exists.

In the collateral requirement calculations the haircuts were adjusted upwards to reflect the real remargining period, i.e. three months, to take into account the higher volatility during this longer period. The bond and stock price volatilities should be adjusted similarly to see how the volatility is affected by a longer remargining period. However, this adjustment would only mean linearly multiplying the adjusted volatilities to correspond longer remargining periods using again the square root of time formula. This is due to the fact that the volatilities calculated for the instruments for minimum holding period and then adjusted to equal the 99% confidence level is actually how Basel II urges banks to determine haircut levels under own estimates approach. Thus the adjusted volatilities here correspond to estimates of haircuts and linear multiplication would yield similar results as the above rationing.

This analysis shows that, as expected, the bond collaterals are the most suitable as collaterals in respect of collateral instrument volatility. Their prices do not change abruptly on average and thus only moderate haircuts are suitable for protecting against this volatility. Equities, on the other hand, are rather highly volatile and haircuts that are large enough are needed. At least in this case, the haircut could prove to be too low and the price of the stock could decrease so much that the equities would be insufficient to cover the exposure.

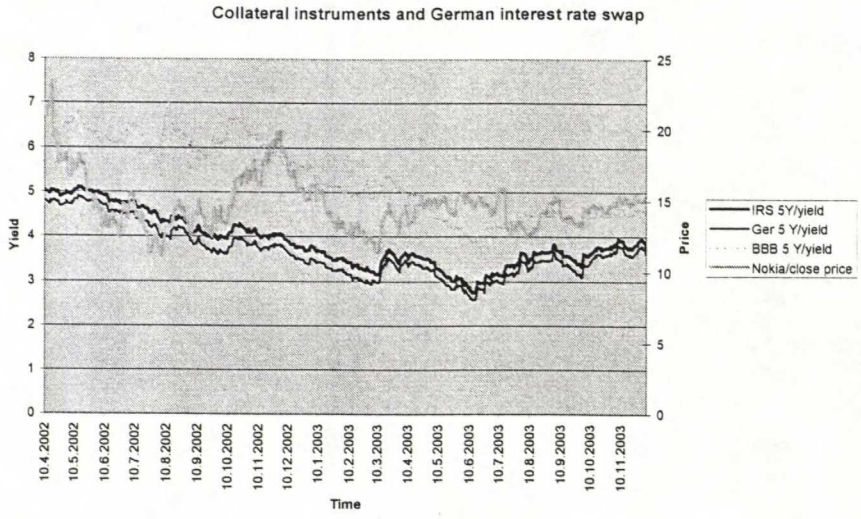
It should be noted, however, that if high haircuts are applied, such as for the equities, and if the price changes are less drastic than expected, the collateral requirements might be too high causing overcollateralisation risk.

8.4.3.2 Collateral instrument correlation with underlying exposure

As the German government bond and StoraEnso Oyj corporate bond are both fixed income instruments and similarly dependent on interest rates as the interest rate swap, it implies that these two instruments should be positively and relatively highly correlated with the interest rate swap. On the other hand, the Nokia Oyj equities are different by nature and thus the correlation is less obvious. Graph 21 depicts all of the collateral instruments' yield or price changes (except cash) with the interest rate swap yield as a function of time for the historical observation period.

Graph 21 German government benchmark bond yield, Eurozone BBB rated corporate benchmark bond yield and Nokia Oyj stock price together with the German interest rate swap yield during the historical observation period

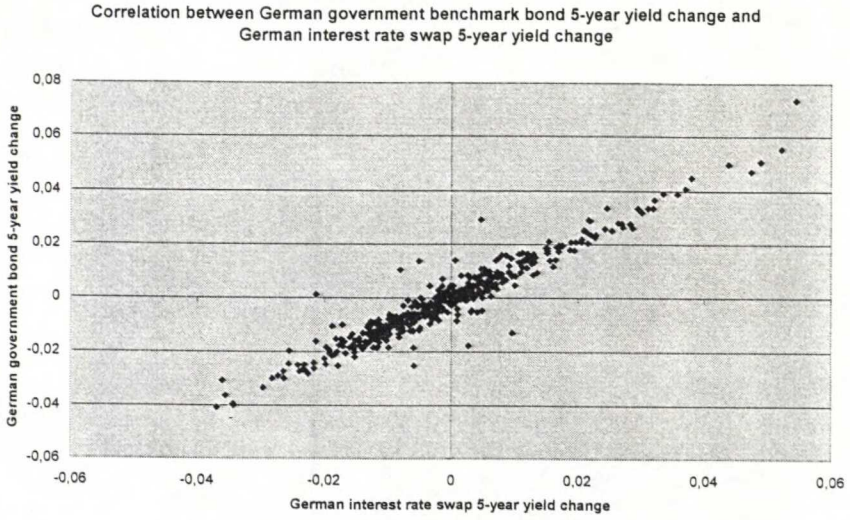
The graph depicts 5-year yields for the bonds and the swap and the stock price for Nokia Oyj during the period of 10.4.2002-5.12.2003



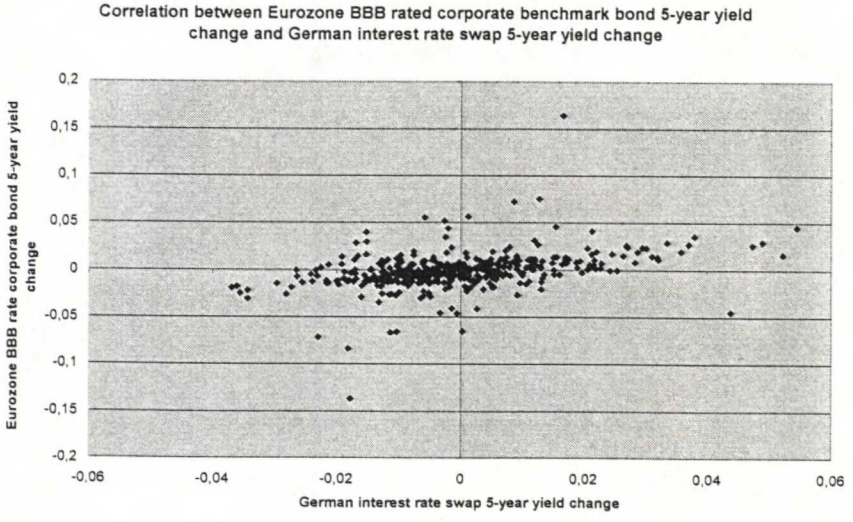
As it can be seen, the German government benchmark bond yield, representing the German government bond used as collateral in this study, seems to correlate highly with the swap yield. Similarly, the BBB rated corporate benchmark bond, representing the StoraEnso Oyj bond, seems to correlate quite a lot with the swap yield. However, the Nokia Oyj stock price behaves quite differently and thus has less obvious correlation with the swap.

In this section, the correlations of the changes in the yields and prices are of particular interest. This is because to evaluate the collateral sufficiency we need to know how the values of the collateral instruments and the underlying exposure change together. If the value of the underlying exposure increases and the collateral value increases similarly, the collateral provides good protection against the movements in the underlying exposure and the collateral covers the exposure efficiently. If, on the other hand, the exposure and the collateral move in opposite directions, the collateral value either decreases and is not sufficient to cover the increased exposure value, or the collateral value increases leading to overcollateralisation if the value of the underlying decreases at the same time. Graphs 22, 23 and 24 show scatter plots reflecting the correlation of each of the collateral instrument price or yield change with the interest rate swap yield change.

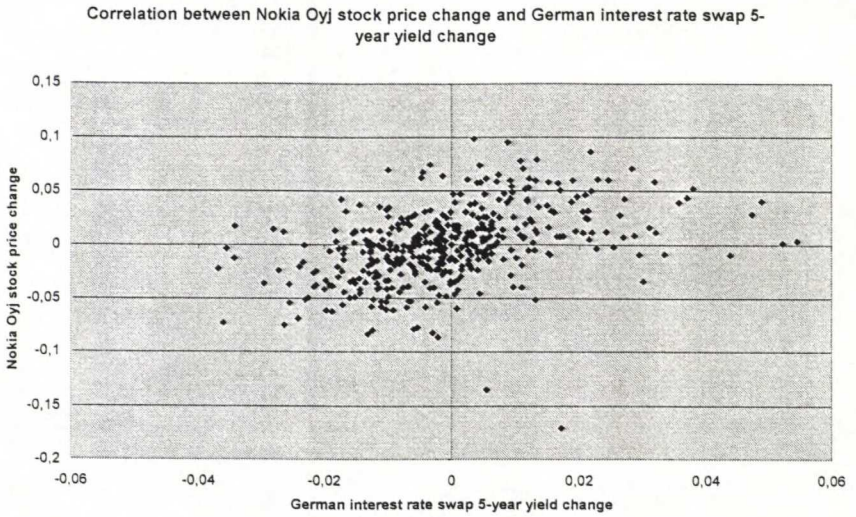
Graph 22 Correlation between German 5-year interest rate swap yield and German government benchmark bond 5-year yield



Graph 23 Correlation between German 5-year interest rate swap yield and Eurozone BBB rated corporate benchmark bond 5-year yield



Graph 24 Correlation between German 5-year interest rate swap yield and Nokia Oyj stock price change



As the scatter plots show, the German government bond is likely to have the highest correlation with the underlying swap if it used as collateral. On the other hand, the Nokia Oyj stock correlates less with the underlying exposure. These correlations correspond actually with the assumptions made in the qualitative risk analysis; bond collaterals have positive correlation with the swap value and the equities are less obviously correlated. Table 15 depicts the correlation coefficients for each collateral and the swap transaction.

	German 5-year interest rate swap	German government benchmark bond	Eurozone BBB rated corporate benchmark bond	Nokia Oyj stock
German 5-year interest rate swap	1,00	0,96	0,39	0,42
German government benchmark bond	0,96	1,00	0,40	0,42
Eurozone BBB rated corporate benchmark bond	0,39	0,40	1,00	0,21
Nokia Oyj stock	0,42	0,42	0,21	1,00

Table 15 Correlation coefficients between the underlying collateralised transaction and the collateral instruments

German interest swap as the underlying transaction, and German government benchmark 5-year bond, Eurozone BBB rated corporate benchmark 5-year bond and Nokia Oyj stock as collateral instruments

Based on the correlation analysis in this section it could be stated that at least with 5-year time horizon the German government bond correlates highly with the interest rate swap and it

provides a rather good protection against movements in the exposure value. Surprisingly, the BBB rate corporate benchmark bond representing the StoraEnso Oyj corporate bond and the equities collateral, i.e. Nokia Oyj stock, correlate very similarly with the underlying exposure. Although it seems based on Graph 21 and on Graphs 23 and 24 that the BBB rated corporate bond would correlate more with the swap than the equities collateral, it is not necessarily true. This is because the interest is in the correlations of the changes in the prices or yields and the swap yield and the stock price can actually change very similarly. This correlation analysis, however, shows only how the prices and yields change together at certain time points and does not take into account a possibility of correlations based on lags between the yields and prices. Nevertheless, this analysis based on correlations between daily yields shows what kind of correlations between the exposure and collaterals exist and what are the implications of such correlations.

None of the collateral instruments show negative correlation with the swap implying that none of the instruments would be unsuitable for being used as a collateral for that reason. Thus all of the collateral instruments would probably provide some cushion against changes in exposure value, with the government bond being the most preferred in this respect. This analysis also shows that although equities as such might have some unwanted features for collateral instrument, they could actually be suitable collaterals at least in this respect. Interestingly, for example the standard supervisory haircuts by Basel II do not take into account these correlations between collateral instruments and the underlying exposure. Although the equities collateral showed high volatility, it could be offset by its positive correlation with the exposure.

9 Summary and conclusions

9.1 Summary

Collateralisation is a widespread counterparty risk mitigation technique. Collaterals are delivered to guarantee the collateral giver's obligation to the collateral receiver. OTC derivatives are the most widely collateralised group of financial instruments and the total amount of collateral in circulation is currently estimated to be about $719 billion, an increase of 65% from year 2002 (ISDA, 2003). Collateral instruments vary depending on the activity and the transaction to be secured, from preferred low-risk cash and government bonds to more risky equity. Nowadays, a wide range of collateral instruments is accepted, e.g. by Basel II

regulations. Collateralisation of OTC derivatives is quite a new phenomenon, especially in Finnish financial markets.

Important future trends in collateral usage will be the scarcity problem of preferred collaterals due to the slowdown in the issuance of these instruments, and thus increased riskiness of the collateral pool. In addition, new laws and regulations related to collaterals, such as the EU Collateral Directive, Hague convention and the new Basel capital accord, will change the laws and rules applicable to collateralised cross-border transactions thus challenging the collateral practitioners.

Using collaterals does not eliminate all of the counterparty risk leaving the collateral receiver exposed to residual counterparty risk and the collateral provider to overcollateralisation and default risk. In fact, collateral usage exposes the collateral users to other kinds of risks, such as legal risk, liquidity risk, operational risk, custody risk, concentration risk and systemic risk. Of these, the residual counterparty risk and legal risk are especially important in the context of OTC derivatives where the counterparty risk is complex due to its market-driven nature and where the need for legal relations in the market to be clear and regulated is critical.

There is only a limited amount of previous research conducted on collaterals. Collateralisation has been studied mainly in credit markets in the context of imperfect information. International organisations and trade associations, such as ISDA and BIS, have conducted another field of study focusing on the current market situation and market practises of collateral usage and on giving instructions and regulations on collateral usage. Very few studies of credit risk pricing have been conducted which take into account the effect of collateralisation and, most importantly, there are very few studies focusing explicitly on risks related to collateral usage.

In addition to presenting an overview of collateral usage and future trends in collateral usage, the purpose of this study was to recognise and study risks related to collateral usage in more detail. After defining the specific risks related to collateralisation all of the risks were studied qualitatively and the residual counterparty risk quantitatively.

9.2 Conclusions and discussion

As the collateralisation of OTC derivatives is a new phenomenon in the market, especially in Finland, and it has been studied only to some extent, this study contributed to see that risks related to collaterals are many and proper ways to evaluate each of the risks are needed. The qualitative and quantitative risk analysis frameworks were suitable for assessing the collateral risks based on the case setting and provided a good starting point for risk analysis. Thus this thesis was an experimental study of collateral risk analysis, as no previous studies or standard ways to quantify collateral risks exist.

The qualitative risk analysis involved evaluating the residual counterparty risk, together with current and future exposure, counterparty rating and collateral riskiness assessments, and legal risk regarding variations in certain areas of legislations between countries. In addition liquidity risk, operational risk, custody risk, concentration risk and systemic risk were evaluated to a lesser extent. The qualitative analysis showed that many of the risks related to collateral usage are somehow managed and as a consequence the systemic risk related to collaterals is reduced. The qualitative analysis thus helped to identify the risk categories with high and low importances and to assess contributors and possible remedies to these risks.

Although deemed critical, especially in the context of OTC derivatives, the legal risk proved to be less extensive, mainly due to the ongoing trend of legislative and regulative reforms. In addition, even though there are various aspects in the legislations that affect collateralisation, especially in cross-border transactions, the legislations in the different case countries did not differ too greatly in these aspects, and the new laws and regulations will further unify legislations. As the *lex rei sitae* rule is applied in all of the case countries, and in many others in Europe actually, the determination of the law applicable to collateral issues is not a major concern. The location of the securities, however, could be more difficult to define, but again, the case countries' legislations are rather uniform. Thus perfecting and enforcing the collateral that is the primary source for legal concerns should not be difficult to conduct in the case countries and in Europe in general.

Liquidity risk associated with collaterals is rather well managed, especially if central counterparties are used. However, without such a service, significant liquidity pressures could be realized. As the quantitative risk analysis showed, the exposure of the underlying transaction can deviate from expected, increasing significantly the top-up collateral delivery

requirements thus adding to the liquidity pressures. The trend towards zero haircuts and the extensive use of cash as collateral however keep this risk in minimum. Similarly, custody risk and concentration risks are well managed, as the central counterparties are highly rated and reliable practitioners who provide professional services with segregated collateral accounts, well-developed systems and special concentration limits.

Operational risk was found to be rather high, especially for new collateral practitioners. Collateral management requires proper systems to be able to value collaterals frequently enough, determine collateral delivery and return amounts etc. Possibility to substitute or reuse collaterals further increases the requirements for these systems. For the beginners, such sophisticated systems are not necessarily available or they are not suitable. Manual models with inadequately skilled collateral personnel expose the practitioner to errors, miscalculations and incorrect collateral calls.

The quantitative risk involved assessing the residual counterparty risk in more detail. The analysis showed that residual counterparty risk related to collaterals is multifaceted, depend on many factors and is rather complicated to measure. This risk is of high importance due to exposure volatility, collateral volatility and the time lag between collateral calls. In this study, different methods were used to study different contributors to this risk category, which further complicated the risk measurement.

The scenario analysis together with the Credit at Risk –calculations revealed that the collateral insufficiency due to exposure volatility, and thus the risk that exists regardless of the collateral use, is quite clearly dependent on the amounts applied to different counterparties to determine the collateral requirement. The interest rate swap showed significant, however rather rare, deviations from the expected value, especially for longer remargining periods. The independent amount determined by ISDA proved to be the amount that mainly affects the extent the exposure volatility is protected against and thus the residual counterparty risk reduced between collateral calls. Thresholds and minimum transfer amounts, on the other hand, if used, add to the exposure and thus increase the residual risk. As an example, the conservative scenario with zero thresholds and minimum transfer amounts and rather high independent amounts showed the least of collateral insufficiency. All of these amounts should thus be set with care, and not necessarily only based on the counterparty rating, especially the independent amount. Also the volatility of the underlying exposure should be taken into

account when setting the amounts, as there might be significant deviations leading to insufficient collateralisation, as the CaR-analysis showed.

The collateral instrument riskiness, on the other hand, is mainly taken into account by applying proper haircuts. As the historical volatility analysis showed, the volatilities of the example bond collateral instruments are rather well taken into account by haircuts and the haircuts applied are not too high to cause too high requirements. The equities collateral, however, showed high volatility that could lead to insufficient collateralisation if the equity price deteriorated and thus would cause residual risk. The time profile of the bond volatility was taken into account to see the effect of the remaining maturity of the collateral instrument.

The historical correlation analysis showed that all of the example instruments have positive correlation with the underlying transaction. A bit surprisingly, also the equities collateral correlated a rather lot with the transaction. This would indicate that equities, although presenting high volatility, could have other features that would make it more preferable as collateral. This aspect is nevertheless not incorporated in the haircut determination. The correlation analysis shed additional light to the effect the collateral instruments have on the collateral sufficiency. Positive correlation would most probably imply better sufficiency of collateralisation.

The risks related to collaterals are intertwined to each other. If the counterparty were to default, and the residual counterparty risk would be realized if the collateral were insufficient, also the legal risk could be realized. If there were concerns over the collateral agreement enforceability, collateral liquidation might be delayed and the holding period would become longer thus further impairing the collateral value and liquidation gains. This would also be the time when the liquidity of the collateral instrument would be tested and realized. The volatility of the underlying transaction would also affect the liquidity risk, as large upward deviations in value would trigger high top-up collateral calls. Incorrect collateral calls due to errors in valuation systems would in turn affect the residual counterparty risk, if too low requirements were set. Thus the risks should not be evaluated in isolation from each other.

In the quantitative analysis, in CaR-calculations, 95% and 99% confidence levels were used. Car-values tell the credit at risk over certain time period with rather low probability of occurrence. Thus it should be remembered that the Car-figures only indicate rare cases and in

reality much smaller deviations are likely to happen in the exposure value. CaR-analysis however helps to understand the nature of the volatility of an interest rate swap as a collateralised transaction. In practice, exposures are also revalued usually more often than every three-months, in many cases even daily. This decreases the possibility of large unobserved and uncovered deviations significantly. On the other hand, collateral agreements usually cover all of the transactions with one certain counterparty, instead of one, implying that the combined underlying exposure value is usually much higher and the deviations are more complicated to determine.

9.3 Further research

As in reality many collateral practitioners actually collateralise several transaction at the same time under one collateral agreement, it would be interesting and indeed more practical to evaluate the collateral risks when there is a portfolio of transactions creating the underlying exposure. Also a simulation of collateral instruments and thus a more appropriate view of the collateral instrument riskiness would be of interest for collateral practitioners in current markets. A study with a portfolio of instruments and also simulated collateral values in addition to the simulated exposure would require however a more complicated model and computational power. It would also be worth of studying how other transactions are affected by the use of collaterals, in what form these same risk categories are realised and how important or severe they are related to the collateralisation of these transactions. Such instruments could be e.g. repos where the collateral is an inherent part of the transaction itself and thus the effect of the collateral and the related risks would be realized in a different way. One interesting, however quite different, subject of study could be to assess the incentive and signalling effects that collateralisation has on collateral givers and receivers.

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APPENDIX A. Standard supervisory haircuts

Standard supervisory haircuts

Note: 10-business-day holding period and 99% confidence interval are assumed and daily mark-to-market and remargining are assumed to be conducted.

Issue rating for debt securities	Residual maturity	Sovereigns[1]	Banks/Corporates[2]
AAA to AA-/A-1	≤ 1 year	0,5	1
	> 1 year, < 5 years	2	4
	≥ 5 years	4	8
A+ to BBB-/A-2/A-1+unrated bank securities	≤ 1 year	1	2
	> 1 year, < 5 years	3	6
	≥ 5 years	6	12
BB+ to BB-	≤ 1 year	15	-
	> 1 year, < 5 years	15	-
	≥ 5 years	15	-
Main index equities and gold		15	
Other equities listed on a recognised exchange		25	
Cash in the same currency		0	
UCITS/Mutual funds		Highest haircut applicaple to any security in which the fund can inves	
Surcharge for foreign exchange risk		8[3]	

[1] Includes PSEs which are treated as sovereigns by the national supervisor

[2] Includes PSEs which are not treated as sovereigns by the national supervisor

[3] When there is a currency mismatch, i.e. collateral is denominated in different currency than the underlying exposure, 8 percentage points should be added to the collateral haircut

Source: Applied from BSBC consultative document: The New Basel Capital Accord, 2001

APPENDIX B. Principal Component Analysis

First, the original historical data (37×100) are standardised in order for it to fit to the normal distribution. The correlation matrix, P, for the standardised data is calculated. Next, the spectral composition of P,

$$P = VDV^T \tag{B1}$$

where

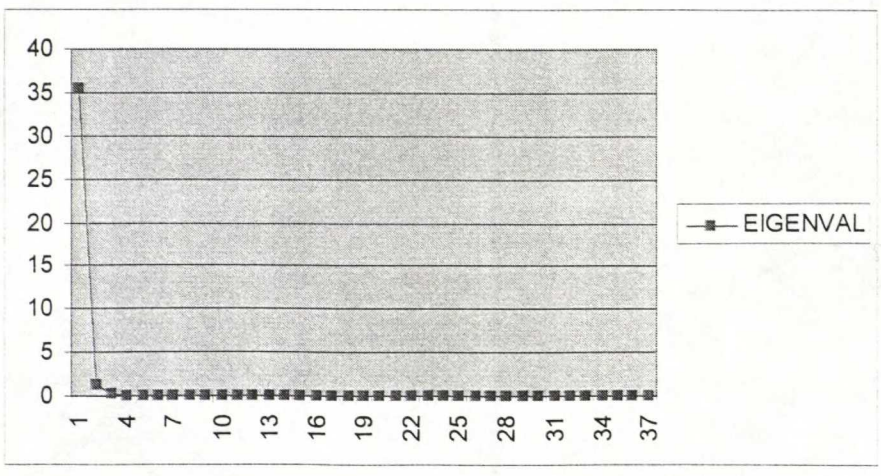
$$V^T = \begin{bmatrix} v_1^T \\ \vdots \\ v_p^T \end{bmatrix}, \qquad v^T{}_i\text{'s are P's } \textit{eigenvectors},$$

and

$$D = \begin{bmatrix} \lambda_1 & 0 & \cdots & 0 \\ 0 & \lambda_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \lambda_p \end{bmatrix}, \quad \lambda\text{'s are P's } \textit{eigenvalues},$$

is calculated. This way the eigenvalues and the eigenvectors of the matrix are determined. The spectral composition is performed using SAS. According to the eigenvalues of the matrix the sufficient number of risk factors is evaluated (there are a maximum of 37 risk factors for this data). As the first two risk factors explain 99,14% of the variation of the original data (see Graph B1 and Table B1), and the additional third and subsequent risk factors add only slightly to the explanation power, the first two risk factors are used. The eigenvectors of these two factors are used as a basis in the calculations.

Graph B1 The eigenvalues of the 37 risk factors.

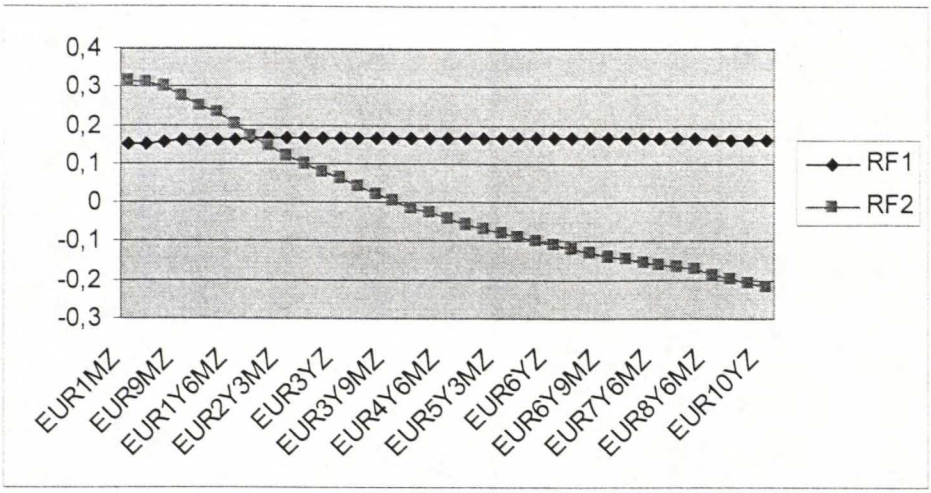


RF	EIGENVALUE	Probability	Cumulative probability
1	35,40704	0,956947	95,69 %
2	1,275909	0,034484	99,14 %
3	0,273644	0,007396	99,88 %
4	0,027322	0,000738	99,96 %
5	0,00551	0,000149	99,97 %
6	0,004098	0,000111	99,98 %
7	0,002277	6,15E-05	99,99 %
8	0,001856	5,02E-05	99,99 %
9	0,000818	2,21E-05	100,00 %
10	0,000619	1,67E-05	100,00 %
11	0,000378	1,02E-05	100,00 %
12	0,000165	4,47E-06	100,00 %
13	0,000141	3,8E-06	100,00 %
14	6,86E-05	1,85E-06	100,00 %
15	4,16E-05	1,12E-06	100,00 %
16	3,04E-05	8,22E-07	100,00 %
17	2,35E-05	6,35E-07	100,00 %
18	1,86E-05	5,03E-07	100,00 %
19	1,28E-05	3,45E-07	100,00 %
20	6,55E-06	1,77E-07	100,00 %
21	5,17E-06	1,4E-07	100,00 %
22	3,25E-06	8,77E-08	100,00 %
23	2,39E-06	6,46E-08	100,00 %
24	1,77E-06	4,78E-08	100,00 %
25	1,43E-06	3,85E-08	100,00 %
26	1,25E-06	3,39E-08	100,00 %
27	7,17E-07	1,94E-08	100,00 %
28	5,15E-07	1,39E-08	100,00 %
29	4,70E-07	1,27E-08	100,00 %
30	4,20E-07	1,14E-08	100,00 %
31	3,57E-07	9,65E-09	100,00 %
32	2,87E-07	7,76E-09	100,00 %
33	2,40E-07	6,49E-09	100,00 %
34	1,84E-07	4,97E-09	100,00 %
35	1,17E-07	3,16E-09	100,00 %
36	9,25E-08	2,5E-09	100,00 %
37	7,43E-08	2,01E-09	100,00 %

Table B1 Eigenvalues for the 37 risk factors and their explanative power

The two risk factors explain the parallel shift of the term structure and the twist of the term structure. The effect of the first risk factor is quite similar across different maturities. The second risk factor cuts the x-axis about at four years maturity implying that the term structure twists at 4 years. Graph B2 presents these two factors and how they explain the movements of the term structures.

Graph B2 The eigenvectors of the first and the second risk factors as a function of maturity



To achieve 'historical values' for the two risk factors, the original standardised data matrix (37×100) is multiplied by the new risk factor vectors, i.e. their eigenvectors (2×37). The resulting matrix (2×100) values are again standardised. With the help of these 'historical values' of the risk factors, the parameters of process, that the risk factors follow, can be estimated.

Each of the risk factors are assumed to follow Ornstein-Uhlenbeck –process (see e.g. Hull, 2000; Gibson, Lhabitant and Talay, 2001; Barndorff-Nielsen and Shephard, 2001). The process takes into account the mean reversion of interest rates, which is important especially for longer observation periods. The formulae for the risk factors is

$$drf_{iT} = \kappa_i(\theta_i - rf_{it})dt + \sigma_i dz \qquad \text{(B2)}$$

where

rf_{it} is the value of the risk factor at time t

drf_{iT} is the change in risk factor from time t to T, t<T

κ is the speed of mean reversion

θ is the long term balance level of the process

σ is the volatility of the risk factor

dz is Wiener process

The estimates for the parameters κ, θ and σ are found using Full Information Maximum Likelihood (FIML) technique applied to the 'historical values' of the risk factors (see e.g. Spanos, 1986). After the estimates are calculated, risk factors can be simulated. Now only two risk factors with 60 time points, i.e. 5 years divided in monthly periods, are simulated, instead of the whole term structures of interest rates in each time point. The random vector $Z=[dz_1\ dz_2]$, $Z\sim N(0,I)$, is simulated several times with Random Number Generator. The simulated values for the risk factors are calculated according to the formulae

$$rf_{it} = rf_{it-1} + \kappa_1(\theta_i - rf_{it-1})dt + \sigma_i dz_i \qquad \text{(B3)}$$

To model the correlation between the term structures, the standardised residuals are calculated for the simulated risk factors. With the help of the correlation matrix of standardised residuals and the Cholesky composition (see e.g. Jorion, 2001), certain correlations between the risk factors can be assigned. This is important since the term structures are highly correlated with each other.

To return the simulated risk factors again into interest rates after each simulation the transpose of the eigenvectors of the risk factors is multiplied by the new simulated risk factors. The resulting values are standardised backwards, i.e. multiplied by the historical volatility and adding historical mean, to yield the estimates for future interest rates. These are in turn turned into discount factors, which are used to calculate the present values of the future cash flows associated with the interest rate swap.

APPENDIX C. Descriptive statistics of the swap value distribution at each time period

1000 simulations

Month 3		*Month 6*		*Month 9*	
Average	-137412	Average	-112919	Average	-168737
Standard error of the mean	47353	Standard error of the mean	58612	Standard error of the mean	62691
Median	-187771	Median	-138151	Median	-78119
Mode	4396	Mode	2261277	Mode	2267634
Standard deviation	1497418	Standard deviation	1853462	Standard deviation	1982478
Variance	2242260908902	Variance	3435321913887	Variance	3930219970313
Kurtosis	-0,090	Kurtosis	0,691	Kurtosis	-0,044
Skewness	-0,016	Skewness	0,116	Skewness	0,007
Range	8065996	Range	11034134	Range	13129922
Minimum	-4589858	Minimum	-4784555	Minimum	-5562951
Maximum	3476138	Maximum	6249579	Maximum	7566971
Sum	-137411763	Sum	-112919114	Sum	-168737302
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	3476138	Largest	6249579	Largest	7566971
Smallest	-4589858	Smallest	-4784555	Smallest	-5562951
Confidence level of the mean(95%)	92922	Confidence level of the mean(95%)	115016	Confidence level of the mean(95%)	123022

Month 12		*Month 15*		*Month 18*	
Average	-146817	Average	-163416	Average	-180301
Standard error of the mean	64149	Standard error of the mean	67348	Standard error of the mean	61966
Median	-97427	Median	-256816	Median	-278900
Mode	3536616	Mode	3650991	Mode	2579748
Standard deviation	2028569	Standard deviation	2129728	Standard deviation	1959535
Variance	4115091139225	Variance	4535742297343	Variance	3839778801718
Kurtosis	0,191	Kurtosis	0,360	Kurtosis	0,604
Skewness	-0,027	Skewness	0,232	Skewness	0,290
Range	12725351	Range	12497141	Range	12621146
Minimum	-6067591	Minimum	-5151580	Minimum	-5811931
Maximum	6657760	Maximum	7345561	Maximum	6809215
Sum	-146816600	Sum	-163415749	Sum	-180300520
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	6657760	Largest	7345561	Largest	6809215
Smallest	-6067591	Smallest	-5151580	Smallest	-5811931
Confidence level of the mean(95%)	125882	Confidence level of the mean(95%)	132160	Confidence level of the mean(95%)	121599

Month 21		*Month 24*		*Month 27*	
Average	-163628	Average	-172899	Average	-44017
Standard error of the mean	60513	Standard error of the mean	55191	Standard error of the mean	52410
Median	-94668	Median	-197210	Median	17969
Mode	77206	Mode	-137956	Mode	-373274
Standard deviation	1913592	Standard deviation	1745304	Standard deviation	1657334
Variance	3661833137626	Variance	3046086628319	Variance	2746757462744
Kurtosis	0,441	Kurtosis	-0,223	Kurtosis	-0,211
Skewness	0,400	Skewness	0,057	Skewness	0,032
Range	11896344	Range	9376153	Range	9572548
Minimum	-5203410	Minimum	-4179788	Minimum	-4357549
Maximum	6692934	Maximum	5196365	Maximum	5214999
Sum	-163628158	Sum	-172899013	Sum	-44016965
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	6692934	Largest	5196365	Largest	5214999
Smallest	-5203410	Smallest	-4179788	Smallest	-4357549
Confidence level of the mean(95%)	118747	Confidence level of the mean(95%)	108304	Confidence level of the mean(95%)	102845

APPENDIX C. Continued

Month 30		*Month 33*		*Month 36*	
Average	-4732	Average	22654	Average	93305
Standard error of the mean	49885	Standard error of the mean	43884	Standard error of the mean	40041
Median	-85765	Median	-19324	Median	257186
Mode	428145	Mode	639670	Mode	1100859
Standard deviation	1577514	Standard deviation	1387739	Standard deviation	1266211
Variance	2488550251291	Variance	1925819561243	Variance	1603289738431
Kurtosis	-0,062	Kurtosis	-0,035	Kurtosis	-0,247
Skewness	0,103	Skewness	-0,046	Skewness	-0,176
Range	9018553	Range	7990920	Range	6692704
Minimum	-4444713	Minimum	-4389596	Minimum	-3446164
Maximum	4573840	Maximum	3601324	Maximum	3246539
Sum	-4731658	Sum	22653682	Sum	93305242
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	4573840	Largest	3601324	Largest	3246539
Smallest	-4444713	Smallest	-4389596	Smallest	-3446164
Confidence level of the mean(95%)	97892	Confidence level of the mean(95%)	86116	Confidence level of the mean(95%)	78574

Month 39		*Month 42*		*Month 45*	
Average	97757	Average	57064	Average	49772
Standard error of the mean	33092	Standard error of the mean	27900	Standard error of the mean	23148
Median	118774	Median	95516	Median	59704
Mode	1354358	Mode	28501	Mode	43584
Standard deviation	1046465	Standard deviation	882268	Standard deviation	732012
Variance	1095089550509	Variance	778397257630	Variance	535841717899
Kurtosis	-0,318	Kurtosis	-0,168	Kurtosis	0,043
Skewness	-0,104	Skewness	0,013	Skewness	-0,051
Range	5279571	Range	4660620	Range	4361229
Minimum	-2589039	Minimum	-2375399	Minimum	-2246893
Maximum	2690532	Maximum	2285221	Maximum	2114335
Sum	97756770	Sum	57063808	Sum	49772082
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	2690532	Largest	2285221	Largest	2114335
Smallest	-2589039	Smallest	-2375399	Smallest	-2246893
Confidence level of the mean(95%)	64938	Confidence level of the mean(95%)	54749	Confidence level of the mean(95%)	45425

Month 48		*Month 51*		*Month 54*	
Average	107371	Average	103996	Average	53353
Standard error of the mean	18745	Standard error of the mean	14322	Standard error of the mean	9594
Median	102226	Median	168710	Median	64918
Mode	334693	Mode	-5381	Mode	47740
Standard deviation	592764	Standard deviation	452909	Standard deviation	303399
Variance	351369662979	Variance	205126991649	Variance	92050661946
Kurtosis	-0,546	Kurtosis	-0,552	Kurtosis	-0,507
Skewness	-0,029	Skewness	-0,120	Skewness	-0,203
Range	2863830	Range	2357828	Range	1683066
Minimum	-1331077	Minimum	-1060517	Minimum	-774191
Maximum	1532753	Maximum	1297311	Maximum	908875
Sum	107370877	Sum	103995991	Sum	53353499
Number of simulations	1000	Number of simulations	1000	Number of simulations	1000
Largest	1532753	Largest	1297311	Largest	908875
Smallest	-1331077	Smallest	-1060517	Smallest	-774191
Confidence level of the mean(95%)	36784	Confidence level of the mean(95%)	28105	Confidence level of the mean(95%)	18827

APPENDIX C. Continued

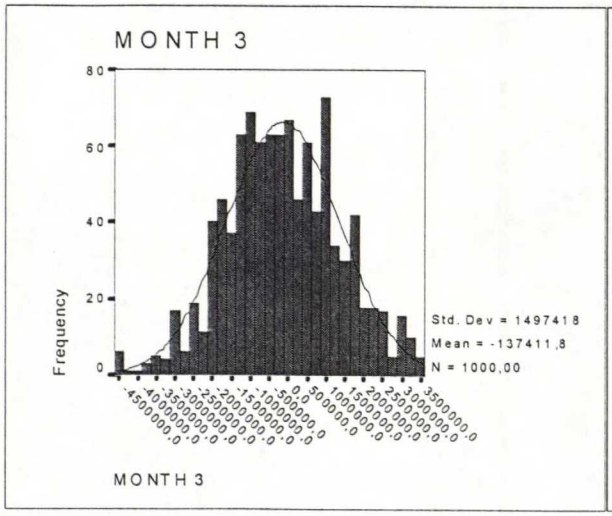
Month 57	
Average	15116
Standard error of the mean	4919
Median	11832
Mode	-8200
Standard deviation	155554
Variance	24196897350
Kurtosis	-0,114
Skewness	-0,013
Range	789912
Minimum	-382663
Maximum	407250
Sum	15115617
Number of simulations	1000
Largest	407250
Smallest	-382663
Confidence level of the mean(95%)	9653

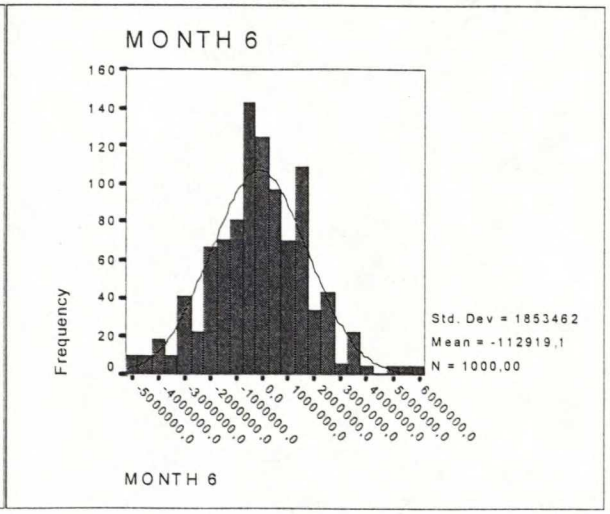
APPENDIX D. Example calculations of collateral requirements / Month 18, German government bond collateral

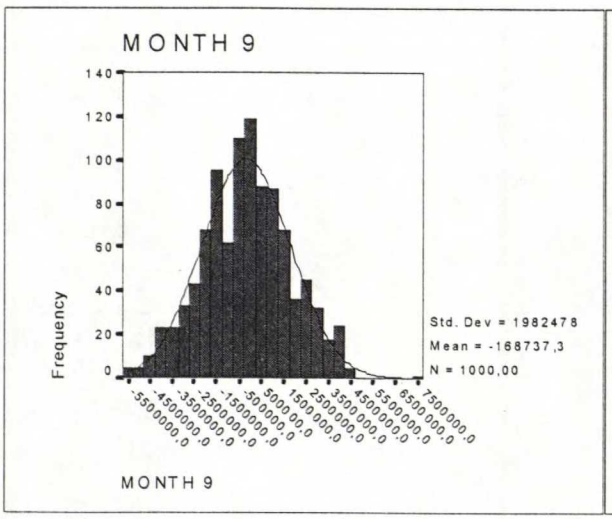
Time point 18/German government bond		Conservative scenario					Base case scenario					The 'trust' scenario				
Haircut			TA	IA	MTA			TA	IA	MTA			TA	IA	MTA
0,053665631	Receiver	AA	0	3 000 000	0	Receiver	AA	35 000 000	0	1 000 000	Receiver	AA	50 000 000	0	10 000 000
TRANSFEROR		A	0	5 000 000	0		A	15 000 000	0	800 000		A	25 000 000	0	8 000 000
		BBB	0	10 000 000	0		BBB	5 000 000	10 000 000	600 000		BBB	5 000 000	0	6 000 000
		BB	0	15 000 000	0		BB	0	10 000 000	400 000		BB	0	0	4 000 000
	Giver	The A inst.	0	5 000 000	0	Giver	The A inst.	15 000 000	0	800 000	Giver	The A inst.	25 000 000	0	8 000 000

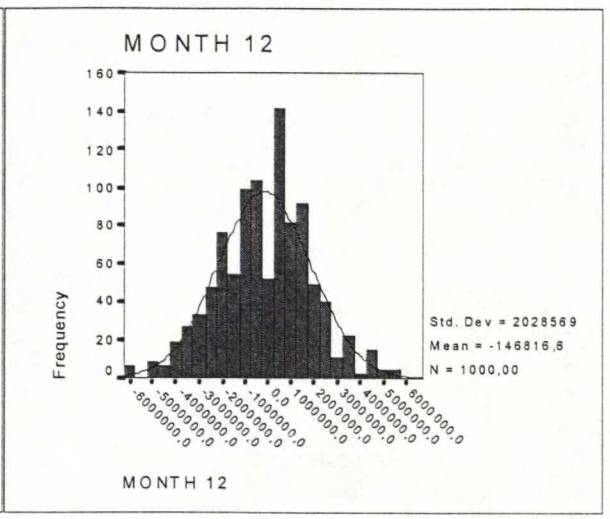
	Conservative scenario	Base case scenario	The 'trust' scenario
AA transferee			
Average exposure of the receiver	180301	180301	180301
Adjusted exposure	180301	180301	180301
+Ind.amount of the giver	5000000	0	0
-Ind.amount of the receiver	3000000	0	0
-Giver's threshold	0	15000000	25000000
Collateral requirement	**2180301**	**-14819699**	**-24819699**
Minimum transfer amount of the giver	0	800000	8000000
Collateral delivery amount	2180301	-14819699	-24819699
Haircut	0,054	0,054	0,054
Real collateral delivery amount	2303943	-15660109	-26227199
A transferee			
Average exposure of the receiver	180301	180301	180301
Adjusted exposure	180301	180301	180301
+Ind.amount of the giver	5000000	0	0
-Ind.amount of the receiver	5000000	0	0
-Giver's threshold	0	15000000	25000000
Collateral requirement	**180301**	**-14819699**	**-24819699**
Minimum transfer amount of the giver	0	800000	8000000
Collateral delivery amount	180301	-14819699	-24819699
Haircut	0,054	0,054	0,054
Real collateral delivery amount	190525	-15660109	-26227199
BBB transferee			
Average exposure of the receiver	180301	180301	180301
Adjusted exposure	180301	180301	180301
+Ind.amount of the giver	5000000	0	0
-Ind.amount of the receiver	10000000	10000000	0
-Giver's threshold	0	15000000	25000000
Collateral requirement	**-4819699**	**-24819699**	**-24819699**
Minimum transfer amount of the giver	0	800000	8000000
Collateral delivery amount	-4819699	-24819699	-24819699
Haircut	0,054	0,054	0,054
Real collateral delivery amount	-5093020	-26227199	-26227199
BB transferee			
Average exposure of the receiver	180301	180301	180301
Adjusted exposure	180301	180301	180301
+Ind.amount of the giver	5000000	0	0
-Ind.amount of the receiver	15000000	10000000	0
-Giver's threshold	0	15000000	25000000
Collateral requirement	**-9819699**	**-24819699**	**-24819699**
Minimum transfer amount of the giver	0	800000	8000000
Collateral delivery amount	-9819699	-24819699	-24819699
Haircut	0,054	0,054	0,054
Real collateral delivery amount	-10376564	-26227199	-26227199

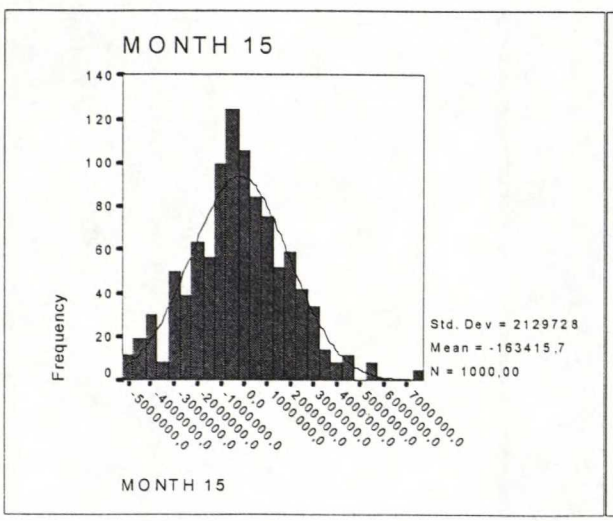
APPENDIX E. Distributions of the values of the interest rate swap in each month and normal distribution curve

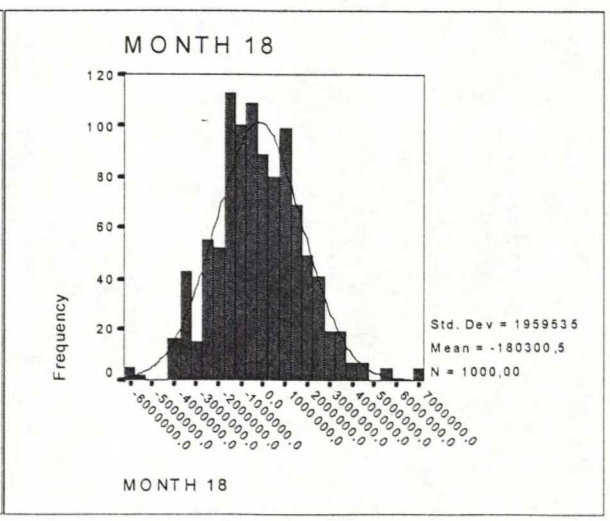




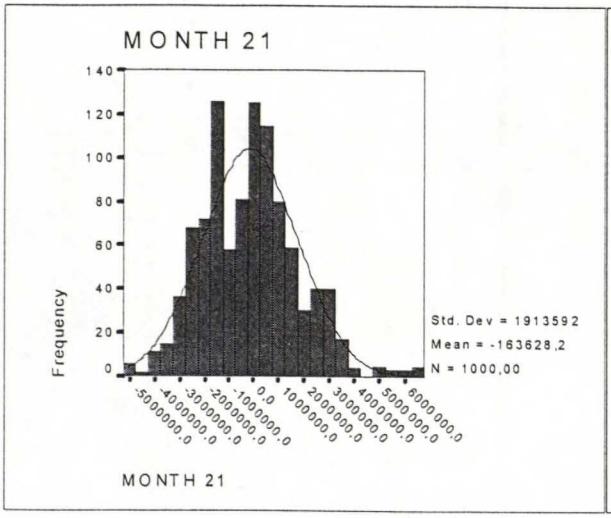


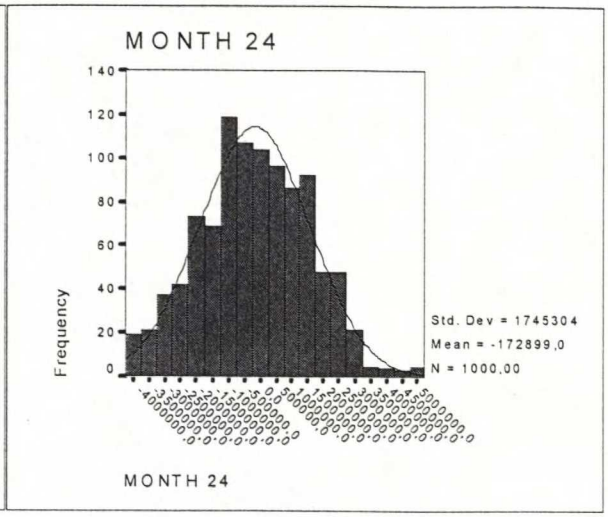


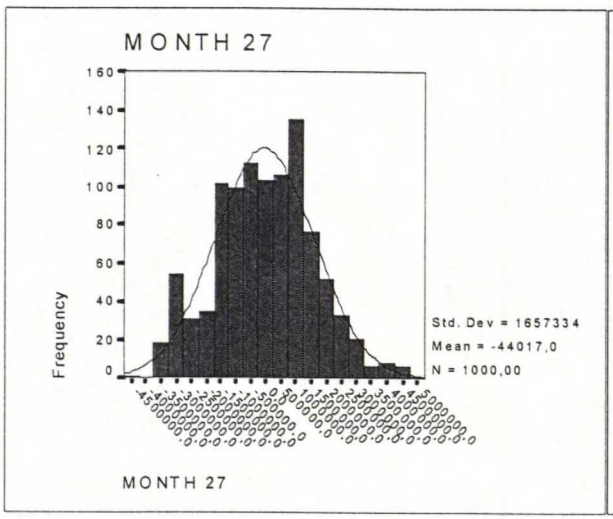


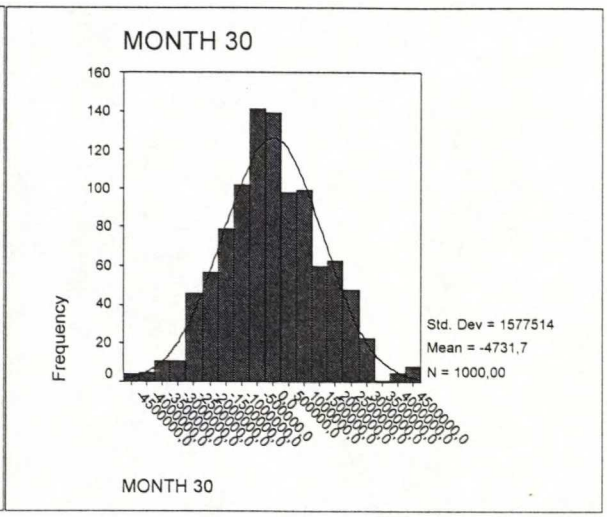


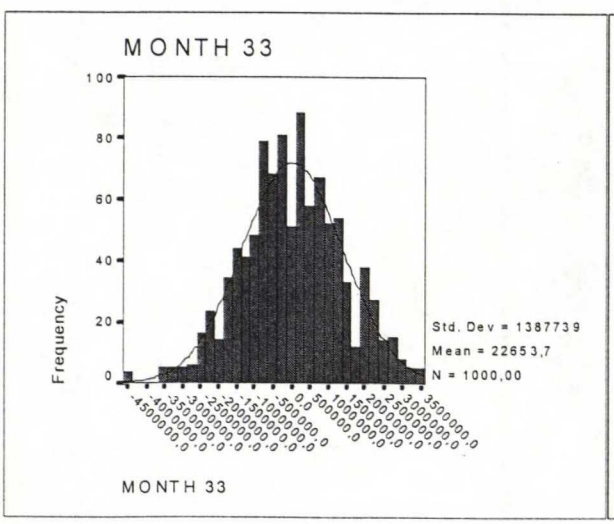
APPENDIX E. Continued

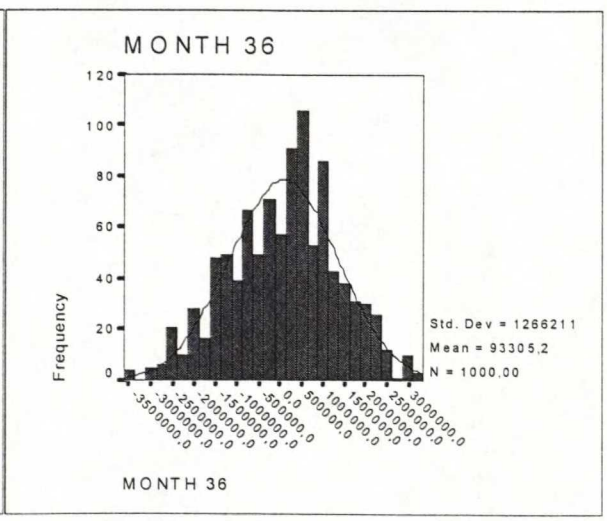




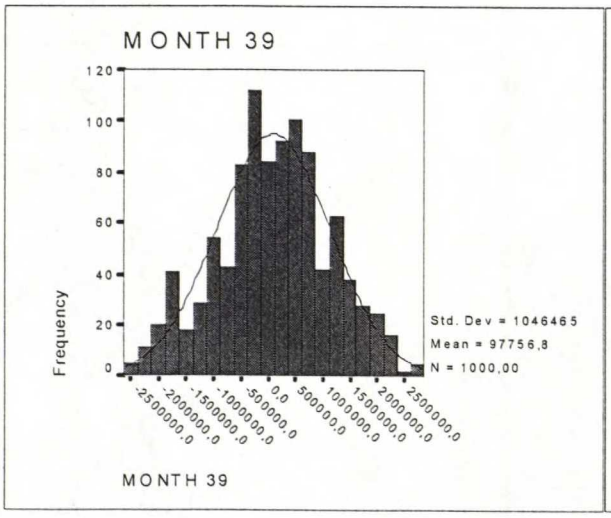


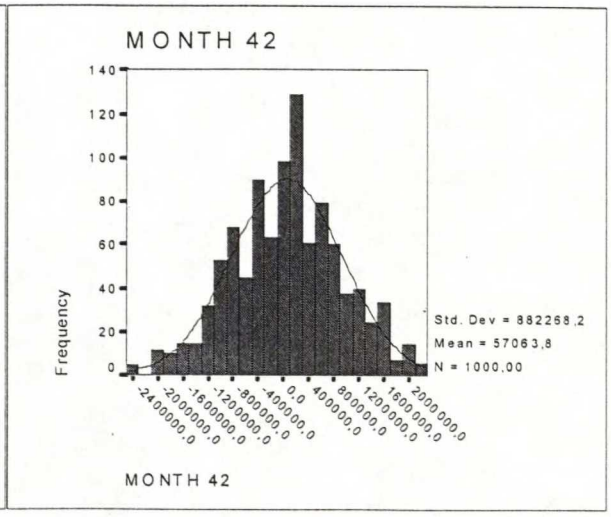


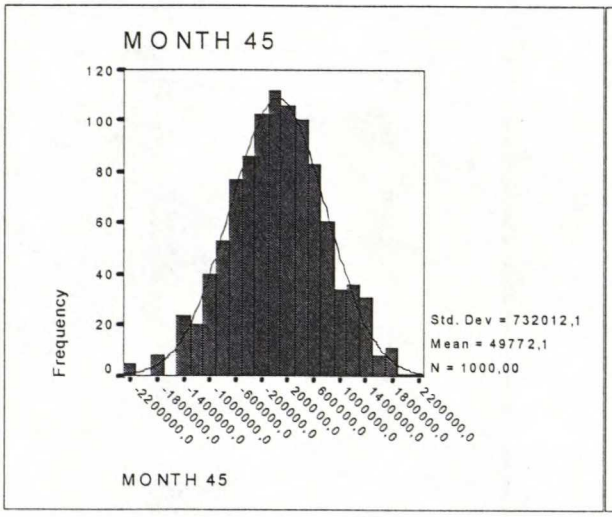


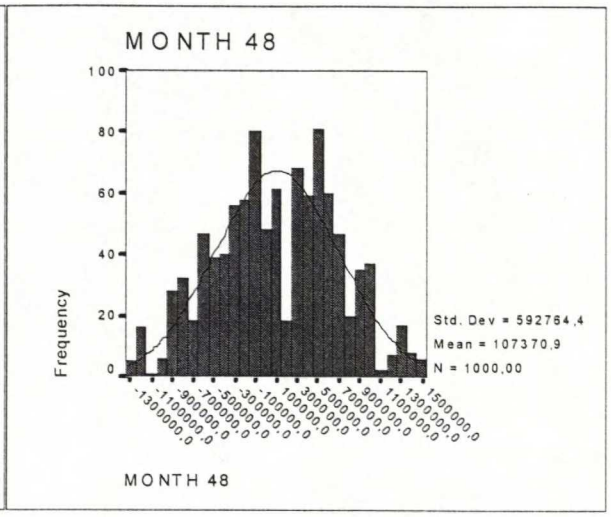


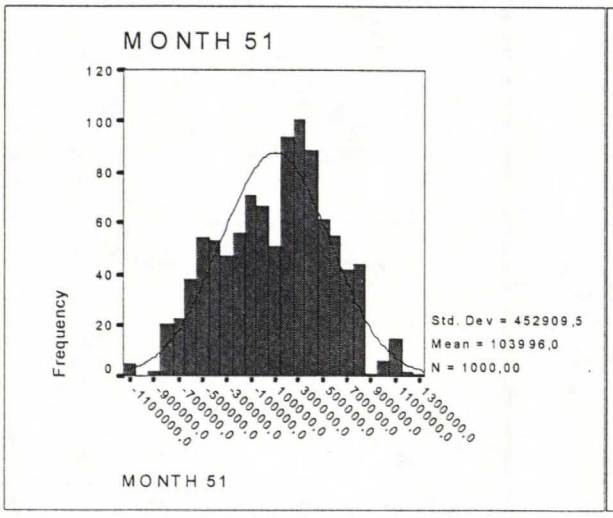
APPENDIX E. Continued

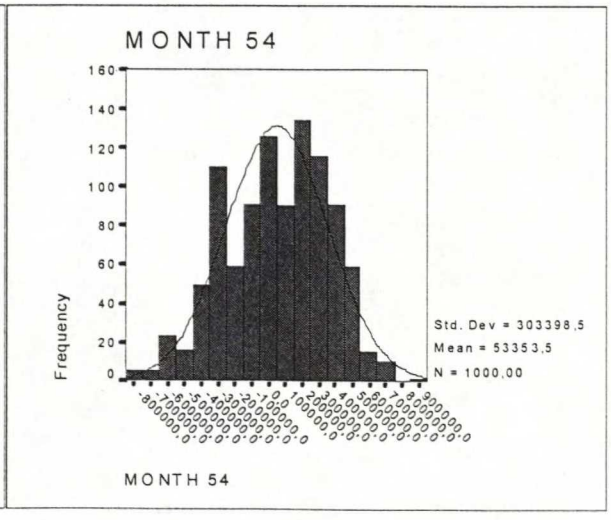




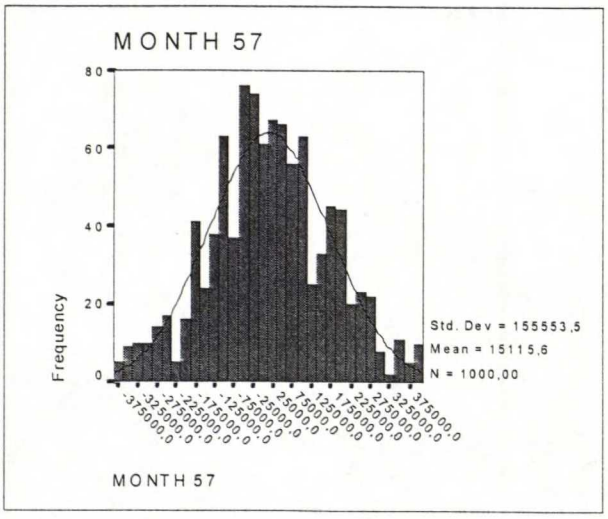








APPENDIX E. Continued



APPENDIX F. Kolmogorov-Smirnov test of normality

One-Sample Kolmogorov-Smirnov Test

		MONTH 3	MONTH 6	MONTH 9	MONTH 12	MONTH 15	MONTH 18	MONTH 21	MONTH 24	MONTH 27	MONTH 30
N		1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Normal Parameters[a,b]	Mean	-137412	-112919	-168737	-146816,6	-163415,8	-180300,5	-163628,2	-172899,0	-44016,96	-4731,6597
	Std. Deviation	1497418	1853462	1982478	2028568,8	2129728,3	1959535,4	1913591,8	1745304,1	1657334,4	1577514,0
Most Extreme Differences	Absolute	,037	,045	,026	,049	,040	,039	,059	,038	,047	,035
	Positive	,037	,044	,023	,028	,040	,039	,059	,020	,028	,035
	Negative	-,024	-,045	-,026	-,049	-,037	-,029	-,032	-,038	-,047	-,024
Kolmogorov-Smirnov Z		1,155	1,437	,808	1,547	1,280	1,245	1,860	1,187	1,472	1,110
Asymp. Sig. (2-tailed)		,138	,032	,531	,017	,075	,090	,002	,119	,026	,170

a. Test distribution is Normal.

b. Calculated from data.

One-Sample Kolmogorov-Smirnov Test

		MONTH 33	MONTH 36	MONTH 39	MONTH 42	MONTH 45	MONTH 48	MONTH 51	MONTH 54	MONTH 57
N		1000	1000	1000	1000	1000	1000	1000	1000	1000
Normal Parameters[a,b]	Mean	22653,676	93305,242	97756,773	57063,809	49772,082	107370,88	103995,99	53353,500	15115,617
	Std. Deviation	1387739,0	1266210,8	1046465,3	882268,25	732012,13	592764,44	452909,47	303398,53	155553,52
Most Extreme Differences	Absolute	,025	,063	,038	,039	,027	,054	,062	,068	,032
	Positive	,023	,024	,031	,039	,027	,037	,046	,050	,028
	Negative	-,025	-,063	-,038	-,023	-,019	-,054	-,062	-,068	-,032
Kolmogorov-Smirnov Z		,802	1,999	1,209	1,237	,856	1,693	1,953	2,136	1,014
Asymp. Sig. (2-tailed)		,541	,001	,107	,094	,456	,006	,001	,000	,255

a. Test distribution is Normal.

b. Calculated from data.

APPENDIX G. Expected exposure, standard deviations and 95% CaR-figures, with three month, one month, ten day and one day time periods, for months from 3 to 57 with cash and equities collateral requirements under the conservative scenario, BB rated counterparty

Month	Expected exposure	SD (per 3 months)	95% CaR, 3 months	95% CaR, 1 month	95% CaR, 10 days	95% CaR, 1 day	CP BB, cash	CP BB, equities
3	-137 412€	1 497 418 €	2 608 152 €	1 563 894€	1 121 778€	448 696€	0 €	0 €
6	-112 919€	1 853 462 €	3 171 132 €	1 878 579€	1 331 340€	498 218€	0 €	0 €
9	-168 737€	1 982 478 €	3 439 826 €	2 057 301€	1 471 970€	580 856€	0 €	0 €
12	-146 817€	2 028 569 €	3 493 955€	2 079 288€	1 480 348€	568 516€	0 €	0 €
15	-163 416€	2 129 728 €	3 677 467€	2 192 254€	1 563 447€	606 145€	0 €	0 €
18	**-180 301€**	**1 959 535 €**	**3 413 534€**	**2 047 009€**	**1 468 452€**	**587 650€**	**0 €**	**0 €**
21	-163 628€	1 913 591 €	3 321 054€	1 986 569€	1 421 577€	561 426€	0 €	0 €
24	-172 899€	1 745 304 €	3 052 651€	1 835 525€	1 320 220€	535 714€	0 €	0 €
27	-44 017€	1 657 334 €	2 778 619€	1 622 840€	1 133 508€	388 544€	0 €	0 €
30	-4 732€	1 577 514 €	2 607 630€	1 507 516€	1 041 751€	332 666€	0 €	0 €
33	22 654€	1 387 739 €	2 312 423€	1 344 653€	934 920€	311 138€	10 022 654€	16 774 098€
36	93 305€	1 266 211 €	2 182 553€	1 299 533€	925 681€	356 526€	10 093 305€	16 892 342€
39	97 757€	1 104 465 €	1 824 424€	1 094 649€	785 678€	315 296€	10 097 757€	16 899 792€
42	57 064€	882 268 €	1 512 806€	897 537€	637 046€	240 470€	10 057 064€	16 831 687€
45	49 772€	732 012 €	1 257 592€	747 107€	530 979€	201 943€	10 049 772€	16 819 484€
48	**107 371€**	**592 764 €**	**1 085 432€**	**672 055€**	**497 040€**	**230 595€**	10 107 371€	**16 915 882€**
51	103 996€	452 909 €	851 297€	535 450€	401 728€	198 147€	**10 103 996€**	16 910 234€
54	53 353€	303 399 €	553 961€	342 379€	252 800€	116 424€	10 053 353€	16 825 478€
57	15 116€	155 554 €	271 779€	163 300€	117 373€	47 452€	10 015 116€	16 899 792€